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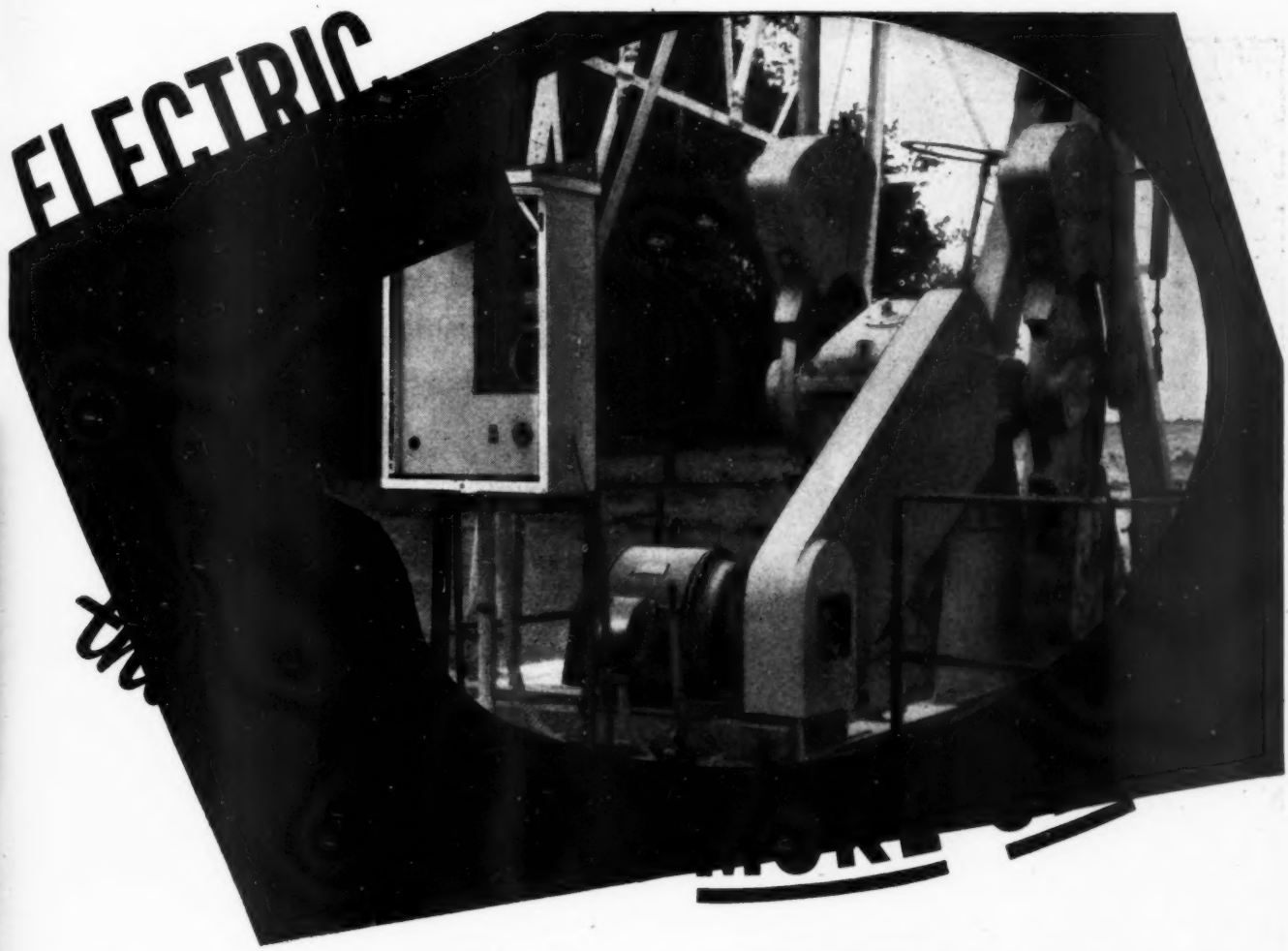

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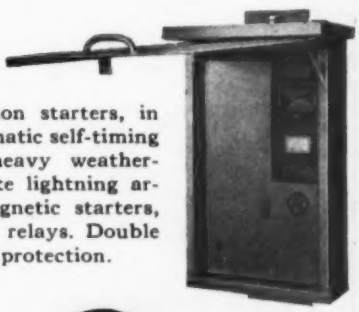

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MEETINGS

May 25-26—A.P.I., Mid-Continent District production division, Mayo Hotel, Tulsa, Oklahoma.

June 1—California Natural Gasoline Association, monthly meeting, Rio Hondo Golf Club, Downey, California.

June 5-7—Society of Automotive Engineers, Book-Cadillac Hotel, Detroit, Michigan.

June 6-8—Southwestern Gas Measurement Course, Norman, Oklahoma.

June 8—Canadian Gas Association, Royal Connaught Hotel, Hamilton, Ontario.

June 13-14—A.P.I., Southwestern District, production division, Rice Hotel, Houston, Texas.

June 24—Kentucky Oil and Gas Association, Lexington.

June 26-30—A.S.T.M., annual meeting, Waldorf-Astoria, New York, New York.

September 20-22—N. P. A., annual meeting, Hotel Claridge, Atlantic City, New Jersey.

October 2-5—A.S.M.E., fall meeting, Cincinnati, Ohio.

October 3-4—American Association of Oilwell Drilling Contractors, 1944 meeting, Fort Worth, Texas.

October 12-13—Texas Mid-Continent Oil and Gas Association, Rice Hotel, Houston, Texas.

October 13—California Natural Gasoline Association, annual meeting, Baltimore Hotel, Los Angeles.

November 13-16—A.P.I. annual meeting, Stevens Hotel, Chicago, Illinois.

March 12-14, 1945—National Association of Corrosion Engineers, President Hotel, Kansas City, Missouri.

★ A comprehensive view of petroleum refining as it is and as it will be appears in the special refining section in this issue. Gustav Egloff gives an inspiring glimpse of refining as a chemical industry. Charles M. Scudder pleads for change in design to save materials in pressure vessels. New modern plants and the latest tested refining methods are described in other articles.

★ ***The Annual Reference Number is published July 1. It contains important papers from leading organizations in the petroleum industry and makes a valuable collection in one volume.***

★ *The Petroleum Engineer* Continuous Tables have brought enthusiastic demands for more from all over the world. Men at home as well as those in far-off countries want the time-saving tables to expedite their work. More than 500 have already been published and are available in bound form for $1, plus a subscription to *The Petroleum Engineer*.

THE Petroleum Engineer

May, 1944

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The Course of Oil

by K. C. SCLATER

TRANS-ARABIAN OIL LINE

Until a report of the recent discussions of the joint British-American Commission is made available nothing definite will be known of the disposition of the Trans-Arabian oil pipe line problem or how it may eventually be settled. In the meantime, because of its far reaching importance with respect to the formulation of a foreign oil policy it continues to be a matter of the greatest concern to the oil industry of the United States.

What action will be taken in regard to the proposed Trans-Arabian oil pipe line must continue to be of the greatest concern to the oil industry of the United States, and rightly so, for if the program as laid out in the "agreement in principle" (the agreement made some time ago between the Government and the three oil companies concerned) were followed it could have a profound effect on the petroleum industry of this country far beyond anything confronted in the history of the industry. Ralph T. Zook, president of the Independent Petroleum Association of America, in an address on this subject last month at Bradford, Pennsylvania, pointed to some of the dangers involved. Among other things he pointed out that no one who is connected with the independent branch of the oil industry, or, in fact, is in any way connected with the oil industry, whether major or independent, has said that the oil reserves of the Middle East should not be developed. What has been said and said many, many times is that they should be developed through private enterprise and private initiative, backed by a strong United States diplomatic policy, as world consumption allows those reserves to fit orderly into the world market.

The laying of a pipe line, however, would not add one new barrel of oil that was not present heretofore.

Because of the economic and competitive conditions in the Middle East, the laying of this pipe line at this time could bring on the market an additional 600,000 barrels of crude oil daily.

On a competitive basis, the Arabian oil could be delivered at New York harbor at a cost of $1.47½ per barrel as compared with $1.62 per barrel for East Texas crude.

This would give the Saudi Arabian oil an 'edge' of 15 cents per barrel over East Texas oil delivered at New York and any refinery would find 15 cents per barrel additional margin most attractive.

This 15 cents per barrel in favor of Middle East oil could very readily become 50 cents per barrel through the elimination of the import tax and profit and the independent domestic producer would be forced out of business even more rapidly than under today's conditions, while the three large companies with the help of the United States government would be breaking even.

At the close of the war a huge fleet of ocean tankers will be available for the movement of oil from the Persian Gulf or any other part of the world where their employment may be desirable. Pipe line construction of the type proposed would render idle a part of this tanker fleet, already financed, whose cost constitutes a portion of the huge war debt. There would thus be duplication of both facilities and expenditures, all of which will be paid by the citizens of the United States.

The oil producer in the United States says, "Give us materials, manpower, and an adequate price for crude oil, and we will find the necessary supply of oil within the borders of the United States." If the oil industry is wrong, then the proper place to overcome the deficiency in oil supply is the Western Hemisphere, our natural sphere of influence. There are hundreds of thousands of square miles of land that have not been prospected in Canada, Mexico, and South America.

What about this one billion barrels of oil reserves for the United States Navy that are mentioned so freely? It is a complete illusion. All the reserves of our nationals wherever situated are available to our country in time of war. The oil reserves of the United States developed by private initiative, private enterprise, and freedom of action are the reserves that are being used to win this war. They are not the reserves of the Anglo-Iranian Oil Company, which are mentioned glibly so many times as an example of the efficiency of government participation in the oil industry by those who are uninformed or who wish to cloud the issue.

What does the independent oil producer believe should be done in this case? The Independent Petroleum Association of America believes:

1. That government of the United States should establish and maintain a consistent foreign oil policy: By giving necessary and legitimate diplomatic support, under the principles of international law, to its nationals engaged in foreign oil operations; by fostering the private enterprise of its nationals in foreign exploration, production, transportation, refining, and marketing of petroleum and its products; by the establishment of a cardinal principle in such foreign oil policy of the government of the United States that the government itself will not directly or indirectly engage in foreign oil ownership, exploration, development, or operation, either in a sovereign or proprietary capacity, or through the media of ownership in corporations or other agencies engaged in the petroleum industry.

2. That if this pipe line is justified by economic conditions, it should be built and owned by the companies. If it is not justified on an economic basis, then it should not be built. Government ownership is not necessary.

3. No shipping space needed to carry on the successful prosecution of this war and no equipment needed in connection with the production, refining, or transportation of petroleum in the United States should be used in the construction of this line or any similar one.

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Highlights IN OILDOM

Arabian Oil and American Policy

"Arabian Oil and American Policy," with particular emphasis on the proposed Arabian pipe line, was the subject of three papers presented before more than 500 members of the Foreign Policy Association at a luncheon meeting held recently in the Waldorf-Astoria, New York City.

FRANKLYN WALTMAN

Dr. Herbert Feis, economic adviser, Department of State (1931-1943) and author of "The Changing Pattern of International Economic Affairs" and other books, was the principal speaker and presented the subject from the viewpoint of its international aspects. Dr. Feis was followed on the platform by Franklyn Waltman, director of public relations, Sun Oil Company, whose remarks were based on the resolutions and reports of the PIWC and the Independent Petroleum Association of America. The final speaker was Bruce Blevin, president and editor, *The New Republic*, whose paper dealt with the layman's point of view.

Anglo-American Oil Board Proposed

Although little has been announced officially concerning the results of the British-American oil talks, from a participant it has been learned that creation of a permanent Anglo-American advisory commission to study world petroleum problems has been recommended.

The commission would have no executive powers and would investigate expanding world demand for oil over a long period in accordance with the principles established by the two governments, it was stated. These principles were based on the Atlantic Charter principle of the open door, equal opportunity, and freedom of access to raw materials.

At the conclusion of the conference the state department announced that the two groups had met "in a spirit of understanding and cooperation" and discussed specific questions such as the 1250-mile American pipe line and proposed new British pipe line in the Middle East, as well as broader problems. Delegations are now reporting the results of the meeting to their governments, the state department stated.

Ease Drilling Control in Illinois

Easing of government controls over the use of critical materials in oil well drilling operations in Illinois, 15 counties of southwestern Indiana, and 15 counties of western Kentucky was announced by Acting Petroleum Administrator Ralph K. Davies.

The action was taken in a revision of Supplementary Order No. 5 to Petroleum Administrative Order No. 11, which covers the use of critical materials in the drilling of new oil wells and the deepening of existing wells in the Illinois basin. The revised order is designed to provide additional drilling to develop the multiple pool fields in this area and, also, to augment the deficient supply of crude oil in the Midwest.

PIWC Rejects Stripper Well Subsidy

The Petroleum Industry War Council has voted to reject the stripper well subsidy proposed by Fred M. Vinson, economic stabilization director, as being "entirely inadequate to meet industry requirements previously recommended by PIWC and the Petroleum Administration for War."

"It is the opinion of the PIWC that a general price increase on petroleum and its products is the proper method of compensating for increased finding, development, and operating cost," the strongly worded statement, which was recommended by the production committee and adopted by the council, asserted.

Excellent Accident Prevention Record

Despite the handicaps of thousands of new and untrained employees, all-time record production, and an 8 per cent increase in hours worked per worker, the petroleum industry retained its fine accident prevention record largely intact in 1943, the American Petroleum Institute's department of accident prevention announces.

The severity rate (number of days lost per thousand hours worked) is lower than in 1942, the annual summary of injuries reveals. The frequency rate (number of disabling accidents per million hours worked) increased 10 per cent, or only slightly more than the percentage increase in number of hours worked per worker.

The 1943 oil company frequency rate of 12.87 was only 11.0 per cent above the all-time low frequency figure of 11.59 reported for 1940. The 1943 severity rate of 1.30 was the lowest on record. The 113 fatalities and permanent total disabilities for 1943 are the equivalent of 33.7 per 100,000 employees as compared to 31 per 100,000 in 1942, an increase of 9 per cent.

Two hundred and two oil companies employing 335,570 persons are included in the 1943 report, which is 22 more companies and 242 more employees than were included in last year's annual summary.

Accident frequency continued to decline in the ocean and coastwise service of marine departments, but there was a sharp increase in severity. The frequency rate declined from 16.79 to 14.29, whereas the severity rate increased to 5.20 from 2.02 in 1942.

The greatest decline in severity rates was in natural gasoline, to 0.95 from 2.63 in 1942.

Klein President The Texas Company

W. S. S. Rodgers, president of The Texas Company since 1933, was elected chairman of the board of directors at a directors' meeting recently and remains as chief executive officer of the company. Rodgers announced that Harry T. Klein, executive vice president and general counsel, was elected president of the company. R. L. Saunders, secretary, was elected a vice president in addition to his former duties as secretary. O. J. Dorwin, associate general counsel, was elected general counsel.

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H. T. KLEIN

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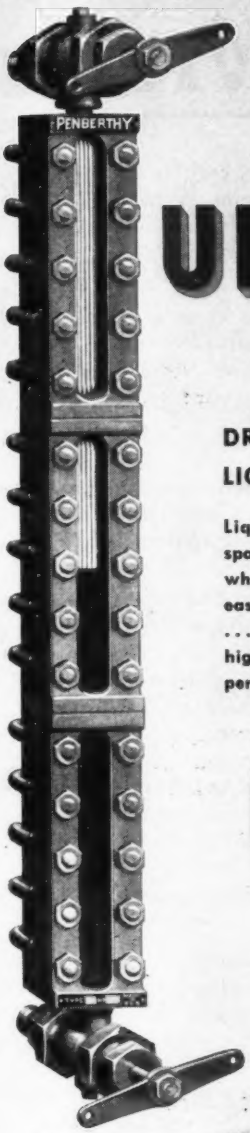

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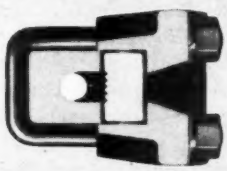

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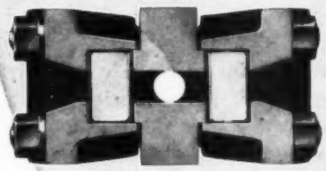

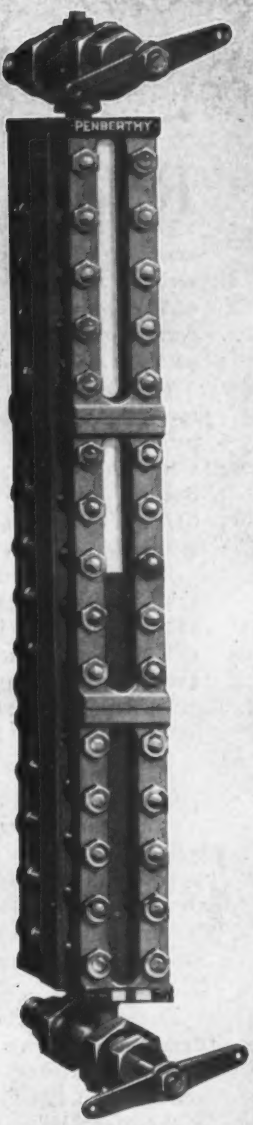

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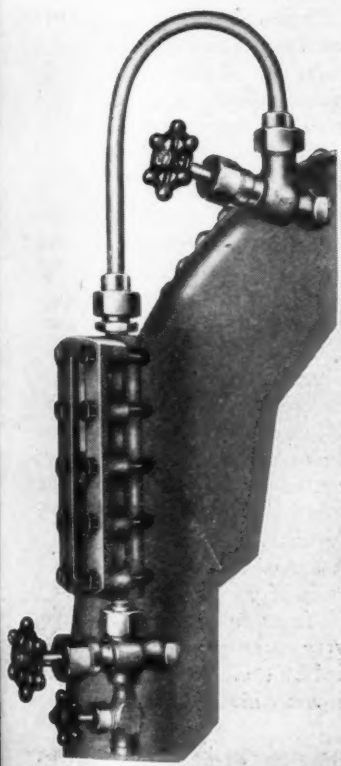

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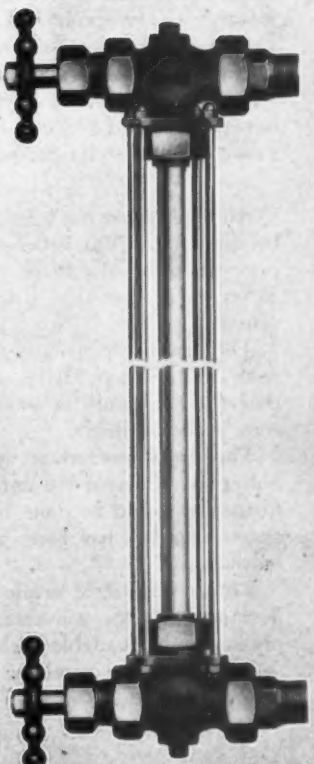

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PENBERTHY PRODUCTS

MAJOR *Pipe Line* ACTIVITIES

REPORTS on pipe line transportation in 1943 to the Interstate Commerce Commission shows an increase of 13.4 per cent in revenue over 1942 and an increase of 17.8 per cent in traffic. Both traffic and revenue are believed to have reached an all time high. Transportation revenue totaled $258,606,801, against $227,967,538 in 1942. Number of barrels originated on line and received from connections totaled 1,908,417,082, against 1,619,579,000.

Humble Pipe Line Company showed the largest traffic and revenue, reporting $22,848,079 on 188,089,693 bbl., a 36.7 per cent gain from 1942. Sinclair Refining Company was second in revenue with $21,575,928 on 107,824,593 bbl.; but Buckeye Pipe Line Company was second in volume with $7,087,423 on 140,860,884 bbl. This volume reflects the large movement of crude oil East by Buckeye.

Refined products carriers with high records were: Great Lakes Pipe Line Company, reporting $10,176,210 on 22,808,850, and Phillips Petroleum, reporting $6,817,597 on 17,405,198 bbl. Carriers showing the largest revenue gains were Tuscarora Oil Company, Ltd., and Portland Pipe Line Company with percentage increases of 150.6 and 100.0, respectively.

Construction of a new pipe line to provide northern Pennsylvania and western New York with additional natural gas was authorized by the Federal Power Commission. FPC said two subsidiaries of the Consolidated Natural Gas Company, the Hope Natural Gas Company and the New York State Natural Gas Corporation, had been issued certificates for the facilities, which it is estimated will cost $3,473,863.

Engineers for the Phillips Petroleum Company said their firm is considering construction of a 24 or 26-in. pipe line from the Hugoton and Panhandle gas fields to serve Wichita and Kansas City. P. McDonald Biddison of Chicago and R. J. Wallace of Dallas, the engineers, said the company had approved tentatively a $20,000,000 expenditure for the line.

Relocation of a major oil pipe line in the basin of the Denison Dam on Red River, made necessary by the impounding of water in the reservoir, will be made under terms of a contract announced by the War Department. The Warren Petroleum Corporation of Tulsa, Oklahoma, was awarded contract to relocate the pipe line in Bryan and Marshall Counties in Oklahoma at a cost of $40,000. The work is to be done under supervision of the district engineer office at Denison, Texas.

An application has been made to the War Production Board by the Pacific War Emergency Pipe Lines, Inc., for materials priorities to build a 20-in. line from Monahans, Ward County, Texas, to Beaumont, California, near the West Coast refinery center.

The new company was organized by West Texas operators with L. M. Glasco, Dallas, as secretary-treasurer. Glasco stated that the line could be moving oil six months after materials were made available.

The line, if authorized, would move approximately 200,000 bbl. a day. Cost of the enterprise would be $47,000,000 and financing would be done by the company itself. No definite encouragement has been given the project by Washington officials.

Recent decline of crude oil stocks in California; increased demand in Pacific war area, and the amount of crude oil supply said to be available in the Permian Basin, make up the basis of argument for installing the pipe line at this time.

The Texas Pipe Line Company expects to complete by June 15 the 34 miles of 6-in. petroleum products line from Lockport, Illinois, to East Chicago, Indiana. Morrison Construction Company has the contract to build the line.

Seventeen miles of 6-in. pipe line will be constructed by Gentry Engineering Company for the Simrall Corporation. The line will be laid from the East Norwich field, Missaukee County, Michigan, south to Leonard Pipe Line Company's Aetna-Prosper main line station.

The Mexican government oil industry said that it is seeking priorities for tank trucks in the United States to relieve railroad congestion that has caused temporary local shortages of gasoline.

Some of the trucks may be used to supply points near the United States where gasoline shortages have been particularly sharp. United States gasoline has had to be imported into Mexico in the Matamoros area, 100 miles north of the oil fields.

At the same time a fleet of tankers will be built for the government petroleum company, according to Miguel Rebolledo, manager of the Maritime Construction Company, Mexico City. This firm holds the contract for building the dry dock and shipyards now being constructed. Some of the 20 to 30 tankers will be of steel and the others of reinforced concrete, it is said. The 15,000-ton tankers will be used to ship Mexican oil all over the world after the war, Rebolledo said.

A 156-mile natural gas pipe line and appurtenant facilities will be built in Kansas by the Kansas-Nebraska Natural Gas Company, Inc., the proposal having received approval by the Federal Power Commission. The company will begin construction before June 1 and expects to complete the work before the end of this year. Route of the line was given in the April issue of *The Petroleum Engineer*.

Contracts have been awarded for 68 additional large ocean-going tankers with delivery by July 1, it was disclosed by the Maritime Commission. It stated the Sun Shipbuilding and Drydock Company of Chester, Pennsylvania, had been awarded a contract for 24 tankers. Contracts for 38 more went to the Kaiser Company, Portland, Oregon, and a contract for 6 ships was given the Bethlehem Sparrows Point shipyard in Baltimore, Maryland.

Present status of the proposal to build the Arabian pipe line is indefinite. The Senate's special oil investigating committee has postponed questioning at the suggestion of Interior Secretary Ickes, who said that it seemed desirable to wait until further study of the world oil situation by the presidential committee, which is headed by Secretary of State Hull.

In the meantime W. S. S. Rodgers, president of The Texas Company, and H. D. Collier, president of Standard Oil of California, made public statements in favor of government participation in the project. The Arabian-American Oil Company, a subsidiary of the companies, together with a subsidiary of The Gulf Exploration Company, would build and operate the line, according to the plan disclosed by Ickes.

The Independent Petroleum Association of America took a stand against government ownership of the pipe line and asked that the government immediately form an integrated foreign oil policy that would foster private enterprise. The statement said that if the pipe line is justified by economic conditions, it should be built and owned by the companies.

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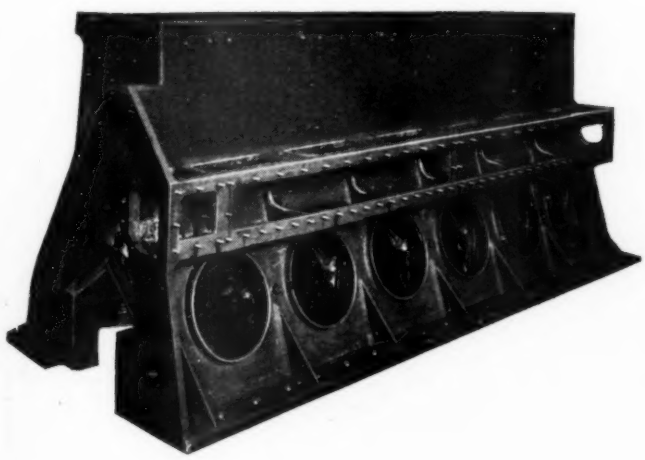

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MAJOR *Oil Field* ACTIVITIES

▶ **Louisiana.** Continental Oil Company has announced discovery of a new pool in the Moss Lake area, Calcasieu Parish. Prairie Land and Canal Company No. 1 came in flowing 20 bbl. an hr. The well is 4½ miles south of the nearest production in the Lockport field. Drilled to 11,319 ft., it was plugged back to 10,455 ft. and perforated in the Hackberry formation from 10,410-20 ft.

▶ **Kansas.** Bridgeport Oil Company No. 1 Beisel, a discovery well in Russell County, was assigned an initial rating of 81 bbl. of oil daily from the Arbuckle at 3294 ft. The location is in SWC NW 15-14-12w.

▶ **Kansas.** C. Elmer Ash and Associates have a new pool opener in the No. 1 Schlochtermeier, SWC SE 5-19-11w, three miles southwest of the Ames pool in Barton county. The well made 17 bbl. of oil an hr. at 3385-3400 ft. in the Arbuckle.

▶ **Oklahoma.** Ohio Oil Company appears to have opened a new pool in the East Pauls Valley area of Garvin County. A drillstem test in No. 1 McKinney, SE NE SE 18-3n-2e, showed oil and the well flowed at the rate of 20 bbl. an hr. along with 5,000,000 ft. of gas. Production is from Pennsylvanian sand at 2866-86 ft.

▶ **Texas.** A new Permian lime pool has been opened by Schermerhorn Oil Company with its No. 1 M. B. McKnight, 2 miles northeast of production in western Crane County. The well flowed 341 bbl. of oil in 24 hr. through perforations from 4490 to 4580 ft.

▶ **Kansas.** Pratt County has a new pool opener, the Lion Oil Company No. 1 Andrew, SE SE SE 24-29-14W. The well has been assigned a potential of 713 bbl. daily from the Simpson sand at 4426 ft.

▶ **Oklahoma.** A new Misener sand pool was opened in Payne County by the Blackwell Oil and Gas Company of Cushing. Its No. 1 Broyles, C S½ NE SW 23-18-4e, had pay sand from 3766-82 ft. A drillstem test showed gas and oil.

▶ **Louisiana.** Discovery of a new oil field has been made by Sun Oil Company whose B-1 E. M. Boagni, 48-8s-4e, flowed 19 bbl. an hr. on test. Drilled to total depth of 10,512 ft. in shale, the hole was plugged back to 9800 ft. and perforated above that depth.

▶ **Texas.** First production in Cameron County comes from the Great Lakes Carbon No. A-1 Yturria, 5 miles southwest of Port Isabel, a commercial gasser flowing 6,000,000 cu. ft. of gas daily. Producing sand was topped at 5980 ft. and perforations were made near that depth.

▶ **California.** A new producing oil sand has been discovered by Continental Oil Company in the San Miguelito field, Ventura County. The Grubb No. 31 produced 1558 bbl. in the first 24 hr. from 7150 to 8259 ft., a zone not hitherto produced in this field.

▶ **Louisiana.** A new salt dome pool on Bully Creek prospect in LeFourche Parish has been opened by Gulf Refining Company. Its Delta Securities No. 6, 36-18s-20e, found 169 ft. of well saturated pay through the electrical log. With 20 ft. perforated, the well flowed 189 bbl. Pay zones are 6396-6437 ft. and 6492-6610 ft.

▶ **Texas.** Continental Oil Company and Sinclair Prairie Oil Company opened a new oil pool from the Conglomerate section of the Bend, Pennsylvanian section, with the J. M. Hundley well, D. Martindale survey. Depth is about 6375 ft.

▶ **Texas.** Sun Oil Company has completed the wildcat, Daugherty No. 1, north of the townsite of Winnie, Chambers County, for an initial production of 154 bbl. Production is from perforations at 8757-59 ft.

▶ **Indiana.** Superior Oil Company has completed a four-pay producer, the Mabel Marvel Unit No. 1, SE SE NW 30-2s-11w, which had an initial production of 180 bbl. a day. Oil saturation was found in the Cypress sand at 1982-90 ft., in the Paint Creek sand at 2078-92 ft., in the Benoist sand at 2133-35 ft., and in Lower McClosky limestone at 2294-96 ft.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	Indiana	.85-1.25
Texas		Ohio	
North Central	.97-1.25		
Panhandle	.70-1.12	Lima	1.50-1.60
West Texas	.80-1.27	Michigan	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.30
Arkansas	.94-1.36	Corning	1.31

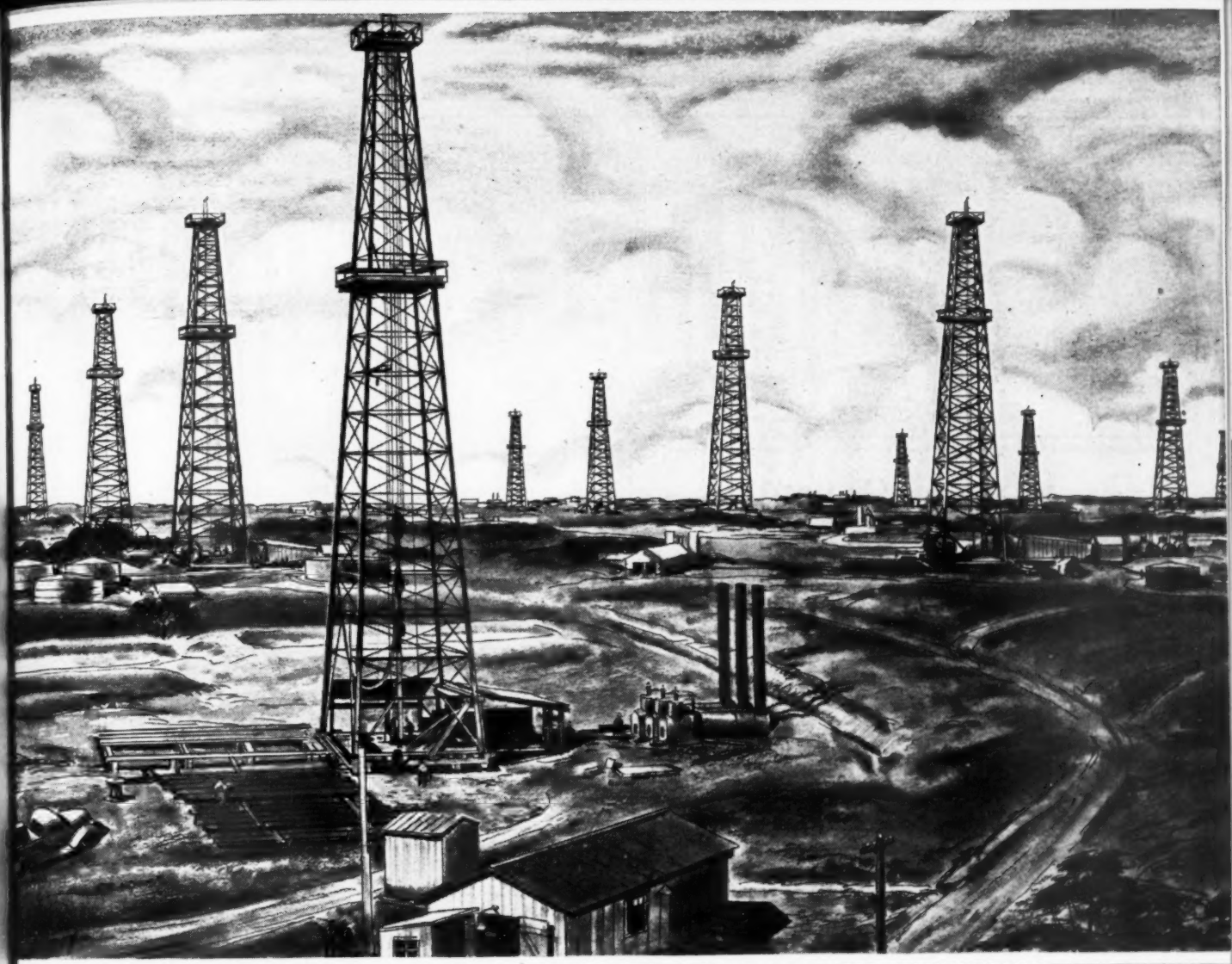
DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

		ACTUAL PRODUCTION		
	*P.A.W. Recommendations April	Week ended Apr. 22 1944	Week ended Mar. 25 1944	Week ended Apr. 24 1943
Oklahoma	328,000	335,550	329,500	341,450
Kansas	285,000	263,800	274,100	318,800
Nebraska	1,000	1,200	1,350	2,200
Panhandle Texas		91,100	92,850	91,000
North Texas		143,850	142,600	134,950
West Texas		374,000	340,900	214,450
East Central Texas		127,250	116,600	99,700
East Texas		362,300	365,100	319,800
Southwest Texas		293,050	291,500	188,500
Coastal Texas		518,800	513,800	340,750
TOTAL TEXAS	1,916,000	1,910,350	1,863,350	1,389,150
North Louisiana		76,150	76,150	88,400
Coastal Louisiana		282,500	283,950	257,900
TOTAL LA.	347,700	358,650	360,100	346,300
Arkansas	76,700	79,550	79,650	72,200
Mississippi	45,000	42,850	41,500	53,650
Alabama		100	50	
Florida		50	50	
Illinois	215,000	201,700	216,450	225,250
Indiana	13,600	13,850	13,600	12,300
Eastern	72,400	72,500	69,000	75,700
Kentucky	23,000	24,350	22,400	21,150
Michigan	53,000	48,500	50,950	57,100
Wyoming	93,000	98,700	91,350	92,300
Montana	24,000	21,500	20,800	20,250
Colorado	7,000	8,200	8,200	6,850
New Mexico	111,700	112,050	112,850	97,250
TOTAL EAST OF CALIF.	3,612,100	3,593,450	3,555,250	3,131,900
California	829,400	833,900	829,500	780,700
TOTAL U. S.	4,441,500	4,427,350	4,384,750	3,912,600

*P.A.W. recommendations and state allowables, as shown above, represent the production of crude oil only, and do not include amounts of condensate and natural gas derivatives to be produced.



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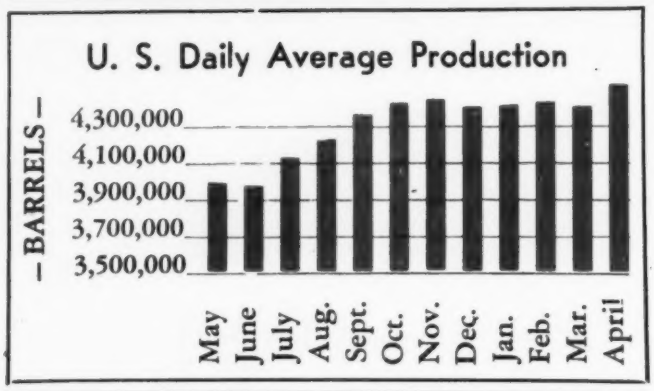
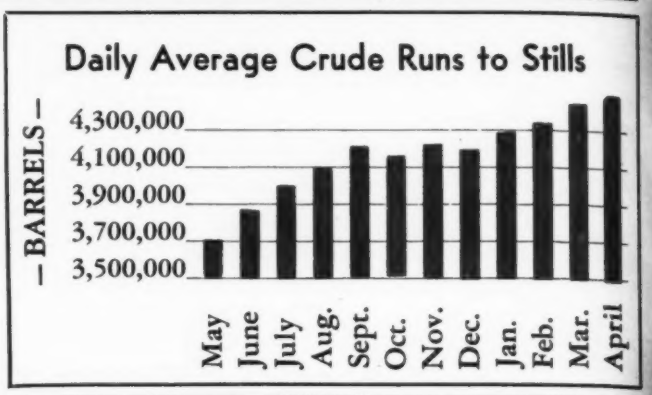
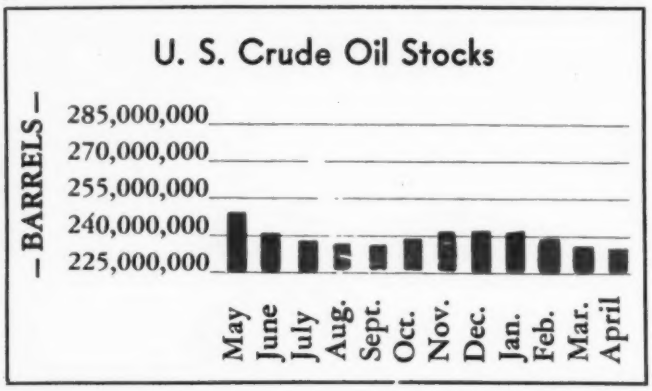
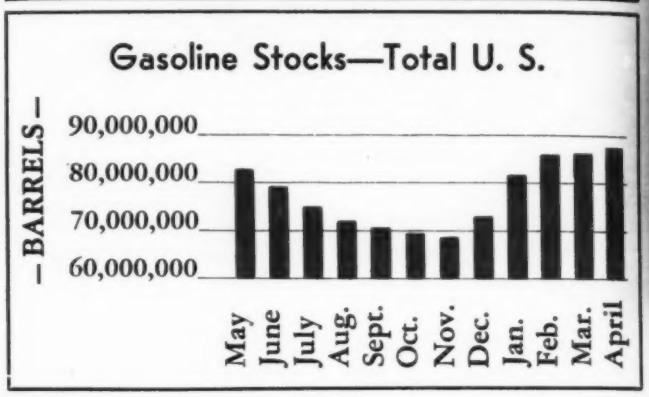
PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for May, 1944

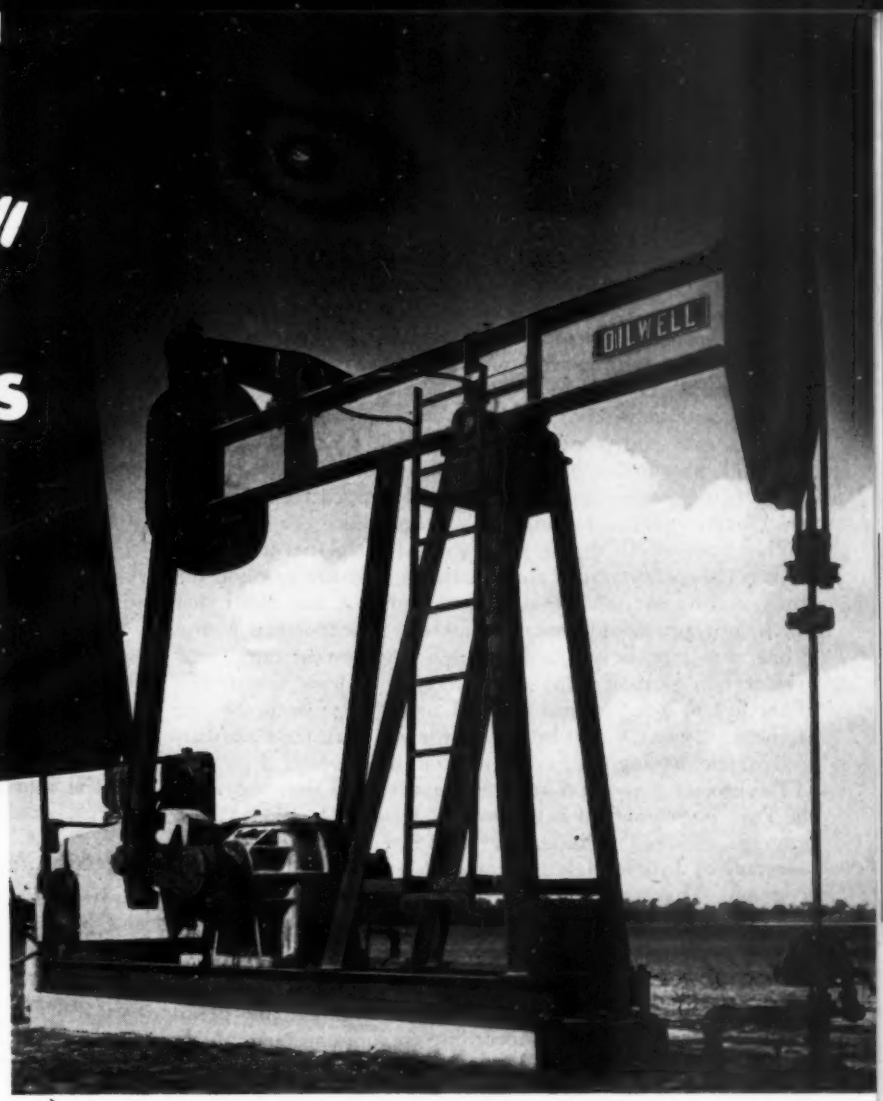
Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
Eastern Texas	17	11	9	....	3500-3700	2&	40	Rotary
Gaines County	36	21	3	....	4400-5584	2&	22-35	Rotary
Hockley County	16	14	9	....	4800-6850	2&	20-30	Rotary
Ector County	21	9	11	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	18	14	7	....	1700-3900	2&	40	Rot.-Cab.
Nueces County	13	15	11	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	17	11	5	....	3730-3935	2&	42-43	Rot.-Cab.
Hawkins Field	9	4	7	13	4495-4912	2&	19-29	Rotary
OKLAHOMA&								
Okfuskee County	3	7	7	....	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	15	13	5	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	6	3	4	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	10	6	5	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	90	80	101	110	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	6	4	3	....	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	15	7	7	4	1840-11,450	2 or 4	14-20	Rotary
Wilmington County	11	6	10	13	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1944

State	Completions April	Completions March	Producers April	Producers March	Locations April	Locations March	Rigs April	Rigs March	Drilling Wells April	Drilling Wells March	Production, 1943 (bbl.)
Arkansas	18	14	10	9	16	11	7	7	13	....	27,605,000
California	97	138	70	106	60	59	36	26	21	16	284,415,000
Illinois	88	156	76	121	81	79	90	80	103	122	81,070,000
Indiana	20	28	18	24	26	33	6	5	14	16	5,320,000
Kansas	141	180	103	132	50	52	23	27	14	25	105,780,000
Kentucky	38	43	27	31	15	21	....	....	....	....	7,890,000
Louisiana	46	42	36	35	24	21	10	....	16	....	125,904,000
Michigan	53	60	46	43	20	31	11	....	13	20	20,576,000
Mississippi	6	4	4	3	....	....	....	....	....	....	18,845,000
Montana	12	21	5	14	....	....	5	7	....	....	7,598,000
Nebraska	....	7	....	5	3	....	....	....	....	....	&791,000
New Mexico	23	29	13	25	11	9	....	....	....	....	38,955,000
New York	96*	98*	88*	85*	49	58	24	15	....	....	4,783,000
Ohio	57	55	45	48	30	28	19	14	....	....	3,220,000
Oklahoma	118	130	97	109	44	41	....	....	46	43	120,880,000
Pennsylvania	207*	218*	183	161	149	161	....	....	....	....	15,986,000
Texas	328	360	250	301	294	311	240	210	290	301	588,560,000
West Virginia	54	76	43	72	22	12	3	3	15	14	3,256,000
Wyoming	6	10	3	8	4	1	3	1	13	5	34,686,000
Total	1408	1669	1117	1352	898	925	471	395	558	562	1,496,120,000

*Includes water-intake and pressure wells.

"Oilwell" PUMPING UNITS



"OILWELL" TC-12C Twin-Crank Pumping Unit for medium-duty service provides many of the high-quality features ordinarily expected only in heavy-duty units. These include the "Oilwell" knuckle-joint unitized pitmans and self-aligning wrist-pin bearings which make it easy for one man to change stroke lengths to meet varying pumping conditions.

TO perform satisfactorily over the life-cycle of a well, a pumping unit must have a wide range of operating flexibility. It must be a smooth-running pumping unit which can be counterbalanced easily and quickly. The unit must be vibrationless at all speeds and have a simple method of changing stroke lengths. "Oilwell" pumping units meet these and other requirements.

Advantages of "OILWELL" Pumping Units

Easy and effective counterbalancing. "Oilwell" Type "B" Adjustable Counterweight Cranks are standard equipment on all heavy-duty units and the TC-12H and TC-17C medium-duty units. All other medium-duty units have counterweight cranks and are also equipped for beam counterbalancing. The light-duty units are counterbalanced by means of beam weights. It is necessary to purchase only enough counterweights to suit individual well conditions.

Wide speed range. Inherent stability, ample strength throughout, and accurate counterbalancing make it possible to operate "Oilwell" pumping units safely over a wide speed range.

Wide selection of stroke lengths. "Oilwell's" self-aligning crankpin bearings and knuckle-joint pitmans facilitate adjusting stroke lengths in the field.

Adaptable to temporary or permanent foundations. The strength and rigidity of "Oilwell" pumping units make them adaptable to temporary wood foundations or permanent foundations which require a minimum of concrete.

Portable. Deep structural-steel base beams facilitate field-transportation and installation. The wide base construction minimizes the tendency to turn over when loading or unloading.

Adaptable to a variety of prime movers. Universal slide rails make it easy to install various types, makes and sizes of prime movers. The flywheel-type pulley smooths out torque peaks and prevents excessive load fluctuations.

Long life and low upkeep result from numerous outstanding construction features, including a positive lubricating system which assures proper lubrication when starting and at all operating speeds.

Wide range of sizes and types. Maximum economy for a great variety of pumping requirements is provided for by the wide selection of pumping units in the complete "Oilwell" line. Please refer to pages 2254-2257 in the 1943-'44 COMPOSITE CATALOG OF OIL FIELD EQUIPMENT or inquire at the nearest "Oilwell" store.

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MAJOR *Refining* ACTIVITIES

THE American-financed $130,000,000 Canol project is ready to begin delivering fuel for the Allied war machine. The refinery at Whitehorse, Yukon Territory, was officially opened April 30 by Canadian and American officials. It is linked by 595 miles of 4-in. aboveground pipe line to the oil source at Fort Norman, Northwest Territories.

The project consists of the wells at Fort Norman, construction of a road and pipe line from the field to the refinery, a 1500-mile network of pipe lines for distribution of the refined products, a power plant dismantled and shipped from Hamilton, Ontario, pump stations, and storage tanks.

The refinery will supply aviation fuel for planes using airfields between Edmonton and Fairbanks, Alaska; gasoline for trucks rolling over the long Alaskan highway, and diesel fuel for use in tractors and similar equipment. The Norman Wells-Whitehorse pipe line is laid through a mountain range and over terrain virtually unknown in prewar days. Ownership of the line will be retained by the United States until the end of the war, when it will be offered for sale with the Canadian government having the first right to purchase.

The project required nearly two years to complete, work on the Fort Norman field beginning in June, 1942. The Canol program received considerable criticism in Congress after Secretary of Interior Ickes denounced it as unsound and uneconomic. The project was carried out by the United States Army.

Its present production required to meet the war needs of the nation, the new Hawkins, Texas, natural gasoline plant is being put into operation, according to announcement made by Warren Petroleum Corporation. Owned jointly by Natural Gasoline Corporation, a Warren subsidiary, and Humble Oil and Refining Company, this modern plant will manufacture various grades of natural gasoline, *iso*pentane, *iso*butane, normal butane, and propane. The plant will be operated by Natural Gasoline Corporation; the output will be marketed by Warren.

Columbia Carbon Company plans to construct a carbon black plant in Terry County, in the northern part of the West Texas Permian basin and south of Brownfield. Construction of the plant may be the result of statutory prohibition of the use of sweet gas for the manufacture of carbon black, necessitating location of plants in the vicinity of unlimited supplies of sour sulphur-bearing gas.

The location of the plant will make available gas from the Slaughter and Wasson pools, two of the largest in the state. The company is reported also to be obtaining right-of-way to build pipe lines to the Hobbs and Eunice pools of Lea County, New Mexico.

The M. W. Kellogg Company has completed consruction of a fluid catalytic cracking unit for the Sinclair Refining Company at Sinclair, Wyoming, which has been on stream continuous without a shutdown since first being put in operation.

The fluid catalytic cracking unit has been designed with sufficient flexibility to produce high yields of aviation base stock and feed stock for alkylation purposes. The unit may be operated on a single pass basis, or the cycle stock may be returned to the reactor for producing increased yields of base stock and alkylation feed stock, depending on the availability of gas oil charge. The unit has also been designed for retreating of the single pass material boiling in the aviation range if desired, and is capable of handling high boiling distillate and residuum stocks for aviation gasoline production.

The unit is complete with the necessary catalyst reservoir and compressors for discharging the gas to the refinery gas recovery unit. Additional problems were encountered in the design of the unit caused by the extremely low temperatures prevailing in Wyoming during the winter months. To counteract the cold it was necessary to provide housing for certain instruments and controls that are normally left in the open.

E. V. Babbitt, president of Clark-Babbitt Industries, Inc., has announced the purchase of the properties, product rights and business of the Madison, Illinois, plant of the Barber Asphalt Corporation, operating from that point. A new company, known as Babbitt-Barber Asphalt Products, Inc., has been organized and will operate the business.

The plant consists of a series of complete manufacturing units located at Madison. The officers of the new company will be Theodore T. Toole, president; Lawrence G. McHugh, vice president and general manager, and Daniel Needham, secretary.

The new twin catalytic plant of Shell Oil Company, Inc., at Wood River, Illinois, was dedicated with great ceremony, the program being carried on the Army hour radio broadcast. The principal address was given by Robert P. Patterson, under secretary of war, who stated the United Nations now are producing 400,000 bbl. daily of 100-octane gasoline. Lieut. Gen. James Doolittle spoke from London; Alexander Fraser, president of Shell, Rear Admiral I. Earle Hipp, and others were on the program.

One of the two new cracking units was the first of its type to be put in operation in the middle West. The two cracking towers are 203 ft. high and occupy an area of 100,000 sq. ft. Much salvaged equipment was used in their construction.

The company has already repaid the loan of $17,500,000 from Defense Supplies Corporation that helped finance the plant.

Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels

Week ended April 22, 1944

A.P.I. Figures

(Figures in thousands of bbl. 42 gal. each)

DISTRICT	DAILY REFINING CAPACITY Potential rate	DAILY REFINING CAPACITY Per cent reporting	CRUDE RUNS TO STILLS Daily average	CRUDE RUNS TO STILLS Per cent operated	Total production[3]	Total stocks[3]
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	2,518	90.3	2,220	88.2	14,417	73,461
Appalachian						
District No. 1	130	83.9	110	84.6	605	3,488
District No. 2	47	87.2	56	119.1	314	1,643
Ind., Ill., Ky	824	85.2	743	90.2	4,738	28,881
Okla., Kans., Mo.	418	80.2	354	84.7	2,107	11,437
Rocky Mt.						
District No. 3	8	26.9	11	137.5	76	138
District No. 4	141	58.3	96	68.1	538	3,207
California	817	89.9	800	97.9	5,390	54,773
TOTAL U.S.— April 22, 1944	4,903	87.3	4,390	89.5	28,185	177,028
TOTAL U.S.— April 15, 1944	4,901	87.3	4,447	90.7	28,933	177,530
U. S.— April 24, 1943			3,743		24,028	194,302

*At the request of the Petroleum Administration for War.

[1]Production—total of gasoline at refineries including natural and blended; kerosine, gas, and distillate fuel oil, and residual fuel oil.

[2]Stocks at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; kerosine, gas oil, and distillate fuel, and residual fuel oil.

[3]Figures on production and stock include reported totals plus an estimate of unreported amounts and are on a Bureau of Mines basis.

THE Petroleum Engineer

MAY, 1944

Power Rigs for Medium Depth Drilling

☆ So-called "spark-plug" rigs adaptable for depths to 7500 ft.

PETROLEUM ENGINEER Exclusive Feature

by Wallace A. Sawdon

Pacific Coast and Foreign Editor

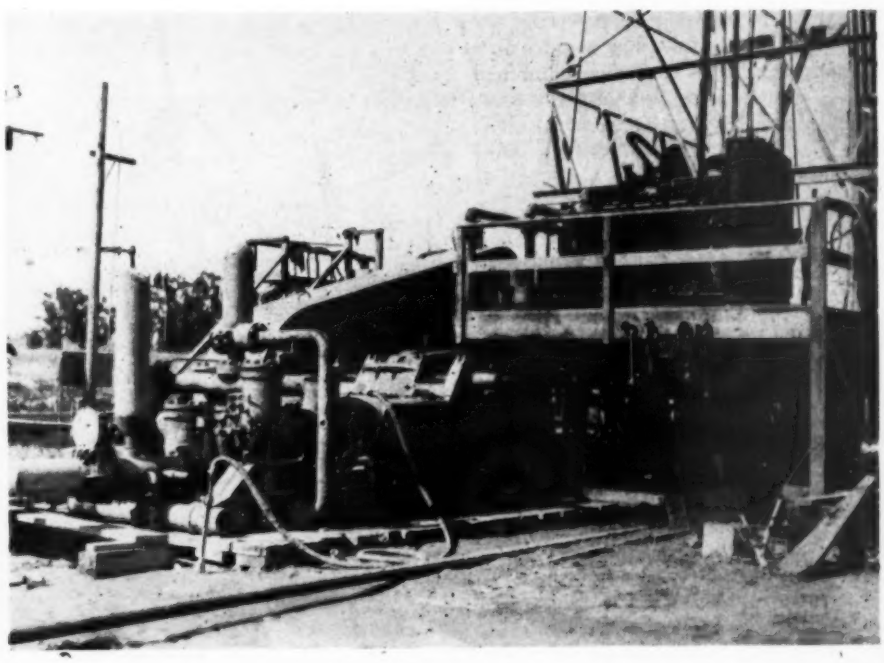
POWER rigs, operating with internal-combustion engines of various types and designs, have been employed for deep drilling for a number of years, but recent accomplishments at record depths have demonstrated their adaptability to meet the greatest depth requirements contemplated at the present time. The full range of efficient power rig performance therefore now extends from that with portable outfits for shallow and relatively shallow wells up to drilling with the heaviest equipment necessary for the deepest holes. The performance of the medium duty "spark-plug" powered rig should also be given due consideration and the work accomplished by one rig of this type during the last year illustrates the adaptability of such rigs for development work at depths to 7500 ft. or somewhat deeper.

Attention at the moment naturally is focused on the deepest well in the world, which may or may not be completed when this goes to press. This well, Phillips Petroleum Company Price No. 1, in Pecos County, Texas, was drilled with internal-combustion engine power, going to below 13,000 ft. with three spark plug engines using butane for fuel. From there to some hundred feet below 15,000, three full diesel engines were employed with a heavier drawworks.[1] In California, a well is drilling below 13,000 ft. with gas engine power, employing the same equipment that has been in service for nearly 4 years.[2] Of particular interest in this rig are the hydraulic couplings between the three engines and their drives to drawworks, rotary table, and mud pumps.[3]

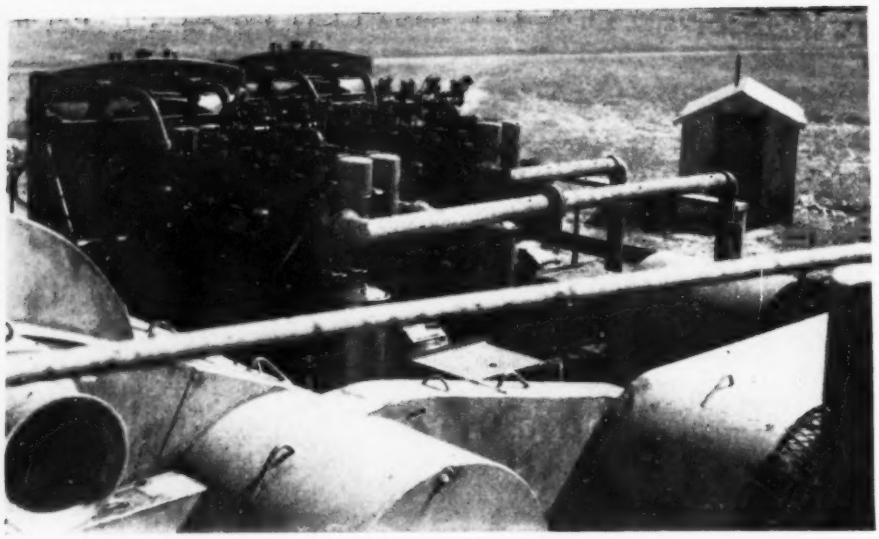
[1]A full description of this equipment is given in "World's Deepest Well Drilled in Texas," by C. C. Pryor, *The Petroleum Engineer*, April, 1944.

[2]Described in "Use of Mechanical Rigs in Deep-Drilling Operations," by Wallace A. Sawdon, *The Petroleum Engineer, November*, 1940.

[3]See "Hydraulic Couplings Promote Flexibility in Control of Drilling Equipment," by Wallace A. Sawdon, *The Petroleum Engineer*, January, 1941.



The mud pump, set beneath the derrick floor, is driven through V-belts by the engines above



Gas engines power the drawworks, rotary table, and mud pump

Equipment found adaptable for medium-depth development work is typified by the consolidated power rig shown in the accompanying illustrations. This rig is unified for transportation by truck from location to location and is designed to accommodate two internal-combustion engines having a maximum combined nominal input of 500 hp. to the drawworks. The rig consists of the drawworks and transmission unit, two engine drive units, and a main sub frame that supports these units as a group and maintains proper alignment. The drawworks and transmission unit actually consists of two units, the hoisting drum unit and the transmission unit, each mounted on a separate skid base.

The main frame rests on a structural steel substructure that is also transported by truck. The mud pump, mounted on skids, is placed on a wooden platform built on the ground below the derrick floor and is driven through a V-belt drive by the engines powering the drawworks and table. The engines may be compounded so that their combined power may be used for hoisting operations or for driving the rotary machine and mud pump at desired speeds while drilling.

The drawworks has 6 hoisting speeds and 3 rotary drive speeds. The transmission is of the heavy duty, oil bath type with 3 forward speeds and gear reverse, including master clutchshaft and jackshaft. A single control over all drawworks operations is provided by means of the master friction clutch, which engages the engine drive. This clutch is of the double disk type with 30-in. friction plates. Power is transmitted from the engines to the master clutchshaft on the drawworks by 1½-in. triple roller chain whereas the compound and mud pump drives are by V-belt. The power pump is 7¼ in. by 15 in.

During the period of little more than a year this equipment has been used to drill 9 wells. It is now drilling its tenth. The rig is owned by Alphonzo E. Bell Corporation and is operating on leases of that company and of the Bel-Air Oil Company. The first two wells were drilled in the Lompoc field and the others in the Santa Maria Valley field. Future locations for the rig will be in these two fields and in Cat Canyon field. Drilling operations are under direction of T. L. Kirchhof, drilling superintendent.

The depths of wells drilled have ranged from 3400 to 5500 ft., but the average has been approximately 5000 ft. The average drilling time per well has been 29 days. The casing program is to set a 11¾-in. surface string and a 7-in. combination string, cementing the upper portion of the 7-in. as a water string above the producing zone. The productive zones have averaged 500 to 600 ft. Derricks are skidded or moved to other locations after completing a well, portable equipment being used for servicing after the wells are on production.

The most recent completion was Bel-Air Oil Company Tonascia No. 1 in Sec. 22, 10 N, 34 W in the Santa Maria field, which discovered a new high pressure gas and oil zone. This well picked up production at 4465 ft. and has 625 ft. of producing formation. The chert and oil zones commonly found in this field were absent and production come from formations underlying these zones. At present the well is producing 200 bbl. of 17° A.P.I. gravity oil per day through ⅜-in. choke, with tubing pressure of 650 lb. per sq. in., and casing pressure of 1000 lb. per sq. in.

This well is only 4600 ft. from the Bell Oil and Refining Company refinery and both gas and oil lines are being laid from the well to the plant for production from this and future wells. The Bel-Air company has more than 2 miles of properties in large blocks along this trend in Sections 22, 23, and 24 in Township 10 N, 34 W and Section 19, 10 N, 35 W. Development of this acreage will augment the present production of Bel-Air Oil Company, which is now 2500 bbl. per day, all of it taken by the Bell Oil and Refining Company refinery.

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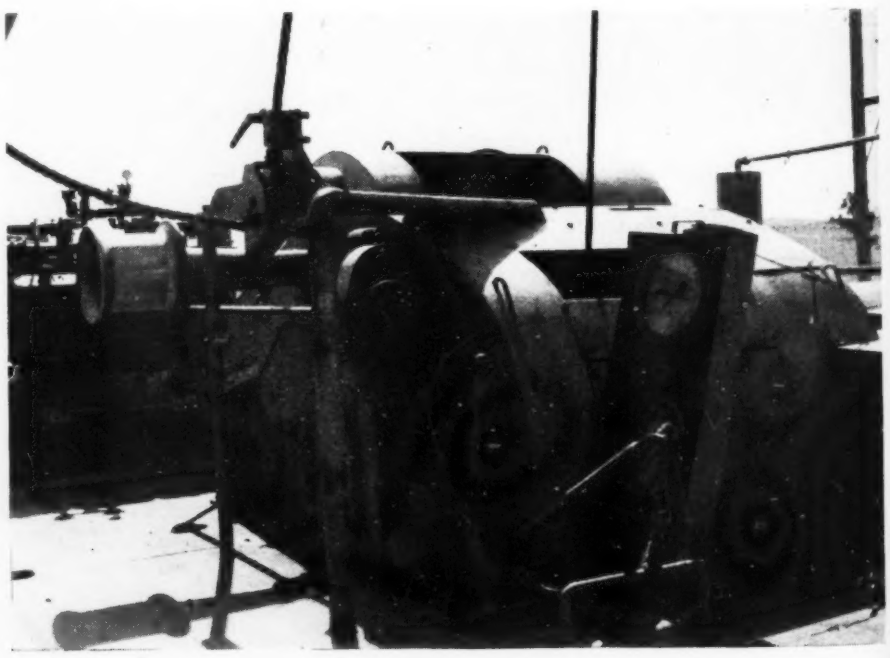


The drawworks is a compact unit mounted on skids

Panhandle Eastern Pipe Line Completes Expansion Program

☆ Main line loops laid and compressors installed to meet increased demand

by J. W. Hall and F. S. Young***

Panhandle Eastern Pipe Line Company

AWARE that the increasing tempo of war production would place greater demands on its system, Panhandle Eastern Pipe Line Company decided to expand its facilities in 1943, despite the difficulties expected to be encountered in procuring material, equipment, and labor.

The system, comprised of field gathering lines in Kansas and Texas, a main transmission line extending from Texas Panhandle to Detroit, with lateral lines to intermediate points in Kansas, Missouri, Illinois, Indiana, Ohio, and Michigan, serves a large area devoted to war production.

The original studies indicated that a 22-in. loop line would be required out of Hansford compressor station, but by a nice balance of sizes and lengths it was found that the required capacity could be obtained by replacing 36 miles of the 22-in. main line between Hansford and Liberal stations with 26-in. pipe. The 22-in. pipe reclaimed from this section was then used to lay loop lines out of Sneed compressor station. Under this plan 2700 tons of steel were saved for use elsewhere in the war effort.

The program adopted called for construction of 8 loops on the main line, totaling:

34.03 miles of 22-in. line,
86.8 miles of 24-in. line,
121.88 miles of 26-in. line (including 1 mile across Beaver River)

Reclaim 35.15 miles of 22-in. line.

Additional compressor installations totaling 24,600 hp.

Location of lines and compressor installations are shown on the accompanying map of the system; however, the first part of the article deals only with construction of loop pipe lines shown in dashed lines.

For purposes of awarding contracts, the work was divided into two sections. The western section, including all lines in Kansas, Oklahoma, and Texas, was awarded to Bechtel-Dempsey-Price of Tulsa, Oklahoma. The eastern section, including all lines in Indiana and Ohio, was awarded to Stanley-Bledsoe Construction Company of Tulsa, Okla.

Construction schedules called for one crew to start on the Olpe loop, one crew on the Liberal loop, one on Beaver River, and one on the Zionsville loop, with an optional additional crew on the Edgerton loop. After some delay the first pipe was received on the Olpe loop July 19, on the Liberal loop July 25, on Beaver River August 25, and on the Zionsville loop August 1. Thereafter pipe was received in quantities up to 5 miles per day, until deliveries of all pipe had been completed. As work progressed, Stanley-Bledsoe decided to place an additional crew on the Edgerton loop and the construction of this loop was begun September 12.

Favorable weather held through the summer and fall and construction was completed and lines placed in service as follows:

Liberal loop, 23.37 miles 26-in., September 26.

Beaver River, 1.00 mile 24-in., September 25.

Hansford main line, 35.15 miles 26-in., November 7.

Edgerton loop, 18.25 miles, 24-in., November 11.

Olpe loop, 26.64 miles, 26-in., November 13.

Zionsville loop, 68.56 miles, 24-in., November 17.

Greensburg loop, 20.19 miles, 26-in., November 18.

Haven loop, 15.53 miles, 26-in., December 12.

Sneed loop and suction, 34.03 miles 22-in., February 29.

The favorable weather, which had held through the summer and fall, was ended in the Panhandle area on December 8 by a severe blizzard, followed by a second blizzard on December 27 and a third on January 7. With the Sneed loop and a portion of the Hansford 22-in. reclaim work incomplete, difficulties multiplied and many construction problems arose. The company decided to continue work on these lines, however, so that the additional facilities would be available at the earliest possible moment.

Design of the lines followed conventional forms, continuing the trend to lighter wall thickness for large diameter pipe. Principal specifications were as follows:

Excavating for water piping at induced-draft cooling tower

*Engineer in charge of pipe line construction.
**Engineer in charge of compressor station construction.

Sneed loop

22-in. O.D. by 5/16-in. wall thickness. Average length of joints 30 ft. Reclaimed from Hansford main line.

Joints—Alternate welded and coupled, with Dresser style 38 coupling every 60 ft.

Coating—Coal tar plasticized enamel used for both pipe and couplings.

Hansford main line

26-in. O.D. by 1/4-in. wall thickness. A. O. Smith electric welded plain end pipe 40 ft. lengths.

Joints—All welded, electric arc.

Coating—Coal tar plasticized enamel with one bonded wrapping of kraft paper.

Liberal loop, Greensburg loop, Haven loop, Olpe loop

26-in. O.D. by 9/32-in. wall thickness. A. O. Smith electric welded plain end pipe 40-ft. lengths.

Joints—Alternate welded and coupled. Electric arc weld-Dresser style 38 coupling.

Coating—Coal tar plasticized enamel with one bonded wrapping of kraft paper. Used for both pipe and couplings.

Zionsville loop and Edgerton loop

24-in. O.D. by 9/32-in. wall thickness. A. O. Smith electric welded plain end pipe 40-ft. lengths.

Joints—All welded, electric arc.

Coating—Coal tar plasticized enamel with one bonded wrapping of kraft paper.

Beaver River crossing

24-in. O.D. by 3/8-in. wall thickness. A. O. Smith electric welded plain end pipe 40-ft. lengths.

Joints—All welded, electric arc, with 1/2-in. steel welding sleeves.

Coating—Coal tar plasticized enamel with bonded wrapping of kraft.

Special—Pipe laid a minimum depth of 14 ft. below river bed, with cast iron river clamps every 40 ft.

Orthodox construction methods were used on most of the work. On the eastern section the contractor used the head-welding procedure for laying the Zionsville loop, but found the stovepipe method better adapted for the shorter Edgerton loop. Most of the bending on the Zionsville loop was done by the fire-bend method but on the Edgerton loop a C-R-C machine for cold bending was used with considerable success. Pipe was cleaned and coated with line-traveling type machines. Bending was done ahead of painting operations.

A high rate of progress was maintained by the contractor on the Zionsville-Edgerton loops by having a special gang install road, creek, and river crossings and valve settings ahead of the main laying gang. Delay of the main gang at these points was thus avoided. A large number of drainage ditches and tile were encountered, but with proper coordination of ditching crews no undue delay was experienced.

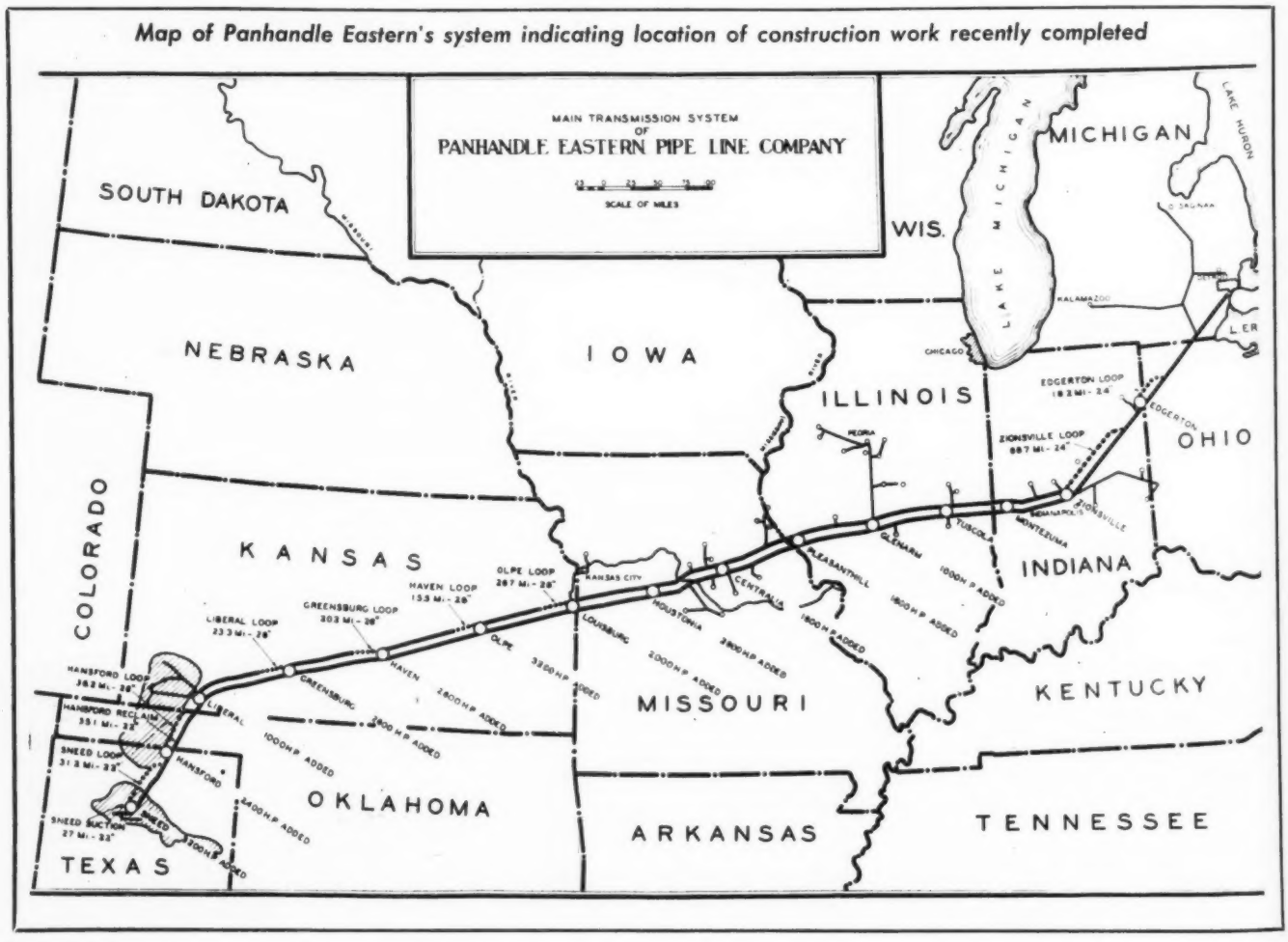
On the western section the contractor used the head-welding method for laying of both alternate welded and coupled lines and solid welded lines. Bends in the 26-in. pipe were made by wrinkle bending. This is a departure from standard practice for this company, and was decided upon as a means of avoiding waste of pipe from buckling, as well as offering a more flexible control of bends.

On the Sneed 22-in. loop where reclaimed lap weld pipe was being used it was found that wrinkles placed across the lap weld seam would cause the seam to open; wrinkles opposite the seam had no effect. Wherever possible, bends reclaimed from the original line were used in relaying the pipe.

Pipe was cleaned and coated by line-traveling type machines, couplings being coated by hand, except that on the Sneed 22-in. line, a line-traveling type machine designed to paint the couplings was used. Coal tar plasticized enamel was used for both pipe and coupling coating, whether couplings were coated by machines or by hand.

The section of 22-in. pipe reclaimed

Map of Panhandle Eastern's system indicating location of construction work recently completed



Making the Mississinewa River crossing on Zionsville loop

had been in service since 1930, and was constructed of 20-ft. random lengths of lap weld pipe, acetylene welded joints with a coupling every 60 ft. The line was stripped with ditching machine to within 4 in. of the top of the pipe and then raised to the top of the ditch and placed on skids. Coupling bolts were cut with acetylene torch and the entire couplings junked. Inspection of the pipe revealed very little corrosion, but the original coating showed sufficient deterioration to warrant recoating. The acetylene welds were inspected individually, and those showing defects were cut out at the time the pipe was lifted; the cuts thus made were left to be rewelded when the pipe was relaid. Those welds passing inspection were allowed to remain in the line. Pipe was hauled by truck and strung on the Sneed loop and cleaned by line-traveling type machine in the same sequence of operations as for new pipe.

The 22-in. pipe reclaimed included a multiple line crossing of the Beaver River. At the point of the crossing, the Beaver is a river typical of the Texas Panhandle area, running nearly dry most of the time but subject to sudden and destructive "head rises." Sand banks and channel bed offer little protection during periods of flood. Experience with this river indicated that precautions should be used to protect the installation of lines. It was finally decided to leave the original multiple crossing in the river and install an additional single 24-in. line with interconnecting lines between the two crossings.

The 24-in. pipe was buried to a minimum depth of 14 ft. below river bed. This is below the area of turbulence during floods. Well points were used to carry on excavation to this depth in the sand and as sections of approximately 400 ft. were dewatered and excavated, additional lengths of pipe were added to lengths previously installed. Each weld was reinforced by a ½-in. steel welding sleeve. Pipe was painted and wrapped and the ditch backfilled. Well points were carried forward to the next section and the entire operation repeated.

Cathodic protection against corrosion of the line in the Beaver River area is provided by a windmill type generator and cathodic installation.

Upon completion of construction of individual sections, lines were blown and tested for service. In order to reduce the accumulation of dirt and other matter remaining in the line after construction, a special solution of Aerosol and water between two rubber squeegees was forced through the line by gas pressure. This solution removed any foreign matter adhering to the interior of the pipe, and as an innovation by this company offers a lead for further investigation along this line.

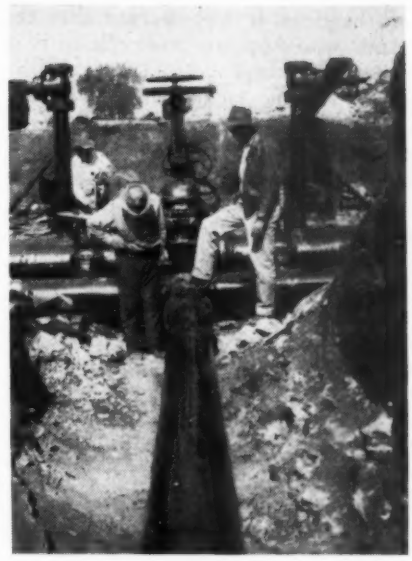
Compressor Stations

In addition to the completion of a major pipe line construction program, consisting primarily of some 200 miles of main line looping, Panhandle Eastern Pipe Line Company has recently completed the installation of 24,600 additional compressor hp. in its existing main line compressor stations.

Engineering studies of main line capacity requirements for peak load conditions, indicated that the economic balance of the company's system with respect to pipe and power called for a compression ratio of 1.60 as a basis for compressor station horsepower design and the conclusions of the studies resulted in the installation of additions to all main line compressor stations from Texas to central Illinois. A tabulation of additions to the stations and their relative location on the system map is as follows:

Station	Location	Additional hp.	Total hp.
Sneed	Stinnett, Texas	4- 800 Ingersoll-Rand	11,000
Hansford	Hitchland, Texas	4- 800 Ingersoll-Rand	8,400
Liberal	Liberal, Kansas	1-1000 Cooper-Bessemer	11,000
Greensburg	Greensburg, Kansas	2-1300 Cooper-Bessemer	10,400
Haven	Haven, Kansas	2-1300 Cooper-Bessemer	10,400
Olpe	Olpe, Kansas	4- 800 Ingersoll-Rand	11,000
Louisburg	Louisburg, Kansas	2-1000 Cooper-Bessemer	9,000
Houstonia	Houstonia, Missouri	2-1300 Cooper-Bessemer	9,100
Centralia	Centralia, Missouri	2- 800 Clark Bros	9,400
Pleasant Hill	Pleasant Hill, Illinois	2- 800 Clark Bros	9,400
Glenarm	Springfield, Illinois	1-1000 Cooper-Bessemer	8,000

Contracts for the construction of the compressor station additions were let to three engineering firms, The Fluor Corporation, J. F. Pritchard and Company, and Midwestern Engineers. To expedite the completion of the jobs and also to compensate for the unknown element in labor costs during this present emergency, the contracts were let on a lump sum fee basis plus payment of actual incurred labor costs. This fee arrangement was satisfactory insofar as the company was concerned, especially in times of labor shortage such as was experienced during this construction.



Inspecting valve installation and tie-in before covering the pipe

The company's engineering department made all designs in connection with the compressor additions, and its purchasing department purchased all material for the complete installation of the new additions. Resident engineers in the field helped to expedite the actual construction of the work after having spent several months in the office familiarizing themselves with construction drawings and company policies. Close contact between the contractor and the company was maintained at all times as the company was directly responsible for expediting delivery of material necessary to keep the contractor's forces busy and the various jobs moving.

The actual design of the plant additions entail some special features that are worth mentioning.

Jacket water systems. Prior to 1943 the company's jacket water system for compressor and engine cooling water was of the open hot-well type, using atmospheric cooling towers for a cooling medium. Atmospheric towers have proved very satisfactory to date, especially when load factors were not as great as called for by present requirements. As the proposed load design called for a high capacity factor, with compressors operating the greater part

of the time, it was decided that the plants would operate more efficiently if a mechanical type induced draft cooling tower for the jacket water were installed. The basic plan of installing mechanical cooling units called for two separate water systems — mechanical towers cooling jacket water and atmospheric towers cooling compressed natural gas.

In the mechanical towers, jacket water can be carried at a higher even temperature for safe engine operation than would be permitted if atmospheric towers were used because radical weather changes have no appreciable effect on cooling by a mechanical tower. This type operation tends toward an even distribution of heat load resulting in more efficient engine operation. The mechanical tower has a pumping head approximately 20 ft. less than that of the present atmospheric towers. This decrease in head permits the handling of about 50 per cent more jacket water without the expense of installing larger pumps. Another feature of the mechanical towers is the fact that considerably less makeup water is lost because almost no wind driftage loss occurs in this type of tower.

All water lines were designed to obtain the best free flow conditions possible to and from the basins of the mechanical towers. Bypasses were installed in the auxiliary buildings, which permit plant operators to control jacket water temperature without the necessity of going to the towers and changing valve arrangements when the wind or atmospheric conditions change.

The atmospheric towers, allocated to the cooling of compressed gas, contain single pass gas cooling sections connected in series with main gas inlet and outlet headers. Panhandle Eastern Pipe Line Company deviated from the standard practice of installing additional cooling sections in series by taking the present double pass cooling coils and installing them in parallel to the inlet and outlet gas headers. This arrangement reduced the pressure drop from the outlet of the compressors to the main line outside the plant from about 10 to 12 lb. to approximately 3 lb. Also, the plan of spreading the gas cooling coils did not require the installation of additional cooling equipment, the present coils in each plant being sufficient to give adequate cooling. This was a considerable saving in the cost of cooling equipment considering the number of stations involved. In connection with the spreading of the gas cooling coils in the atmospheric towers, vertical pumps were installed in the basins of the towers, which recirculate the water over and over the coils. Water for makeup for the atmospheric towers under this system was changed from treated to raw water, consequently no softening treatment is necessary for this service.

Gas to gas heat exchanger installation for dehydration service. In the past Panhandle Eastern Pipe Line Company has had considerable trouble in controlling the gas temperature or contact temperature in its glycol dehydration plants. The best designed system of atmospheric cooling tower and coils did not give a low enough average contact temperature to insure complete protection for the company's pipe lines. In the western Kansas territory, where the dehydration plants are situated, there are periods when the wind stops blowing and a calm exists. During these periods, which are rather frequent, gas contact temperatures in the dehydration plant frequently become quite high and the resulting water dewpoint is proportionately high.

By the installation of gas to gas heat exchangers Panhandle Eastern Pipe Line Company has developed a plan of leveling out these high temperatures, using the inlet gas or suction gas from the field as a cooling medium to cool the hot compressed gas going to the dehydration plant. An analysis of the temperatures of suction gas, year in and year out, indicates that temperature of the gas seldom exceeds 65°F. even in late summer and cools down to as low as 40°F. during the winter months. With a properly designed bank of exchangers using this cooling medium, contact temperatures can be held between 55°F. and 70°F. throughout the year. Using these contact temperatures in a properly designed glycol plant, dewpoints can be obtained from 10°F. to 20°F. These values remain more or less constant day in and day out because of the steady and constant temperature of the gas from the field.

This has proved to be an excellent method of dehydrating natural gas without going to the solid adsorbent system with its resulting high temperatures and operating difficulties. A glycol system is a continuously running, easily operated, efficient process that, combined with the gas to gas heat exchangers, brings results that prove very satisfactory for operating a long transmission line at 600-lb. pressure.

Two banks of exchangers were installed, one at Liberal compressor station and one at Sneed station, and up to this time no appreciable change in pressure drop across the equipment (as might be expected if any fouling takes place) has been experienced. Also, original ratings still seem to hold regarding the amount of heat exchanged. The equipment has removable type tube bundles in the event that tubes become dirty.

Water supply problem at Louisburg compressor station. The main line compressor station near Louisburg, Kansas, up to this year, has used an impounded reservoir as jacket water supply for the engines and compressors. Water was pumped from the reservoir into the engines and allowed to drain back into the reservoir where it was cooled by evaporation and aeration. The installation of additional horsepower at Louisburg made it imperative that present practices of cooling water at the plant be changed and a standard hot-well mechanical-cooling tower arrangement correctly designed to carry jacket water loads throughout the year be installed. The company was confronted with the problem of using lake water for makeup, having a hardness of approximately 6 to 10 grains depending on the season of the year. Also the water contained considerable amounts of vegetable matter and suspended material, which made it very unsuitable for makeup water in a hot-well mechanical-cooling tower type of system.

To combat the turbidity of lake water, a stilling pond approximately 200 ft. square was constructed. Water from the lake was pumped into the stilling pond where heavy suspended mud solids were settled out. From the stilling pond the water was gravitated to a compact filter plant. This plant consists of a mixing chamber, two settling basins, two rapid sand filters, clear well, and pump equipment. Powdered alum is fed into the water as it enters the mixing chamber, which causes the further precipitation of the suspended matter in the water by flocculation. From the filter plant the water is pumped to a water softener where it is softened and discharged into the plant system as makeup.

The capacities of the filter plant include the mixing chamber, which is rated at a volume of 4000 gal. with a detention period of 19 min.; the settling basins, which have a rated volume of 52,000 gal. and a detention period of 4 hours; the filters, which have an individual capacity of 100 gal. per min., and the clear well, which has an operating capacity of 6000 gal. or approximately one hour's clear water supply.

The combination of settling basin, filter plant, and Zeolite water treating plant gives an exact method of treating and pumping clear softened makeup water into the new water system at Louisburg.

Completion of the loop line and compressor station program has provided a system rated capacity of 333,000,000 cu. ft. per day of sales. A peak of 357,000,000 cu. ft. has been delivered in one day.

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Corrosion of Buried Metals And Cathodic Protection

PART 3 (Continued)

by M. C. Miller

Electrical Engineer, Ebasco Services Incorporated

Corrosion caused by mill scale. In the manufacture, shipment, handling, and installation of pipe and other buried metals, the surface becomes non-uniformly covered with mill scale, iron oxide or rust, shop paints, greases, and acids. These may cause different potentials along the surface of the metal when buried in soils and create numerous galvanic cells resulting in corrosion. Some of these tend to reduce corrosion because they form high-resistance films on the surface, others tend to increase corrosion.

There is little that can be done about this condition except to provide a protective coating when the metal is buried in corrosive soils. To clean the surface by using wire brushes, sand blast, or chemical solutions may be the wrong action (unless the metal is to be coated) especially if it is to be connected electrically to other buried metals, viz., a section of new bare pipe welded into an old pipe line. The bright surface may be highly anodic to the old pipe and corrode rapidly.

Corrosion caused by scarring surface and threading. Any scarring of the surface of the metal (except galvanized metals) tends to create an anodic spot or area that may result in severe localized corrosion at the spot. Cutting or filing the metal, threading pipe, or cuts left on a pipe by a stillson wrench, may be the source of serious corrosion, as indicated by Fig. 19. Many of these causes can be avoided by careful handling of pipe. A good coating would be helpful on threads and when scarring is unavoidable.

Threading, scarring, or otherwise damaging the surface of buried metals, may constitute one of the serious causes of pipe line corrosion on distribution systems.

Scarring and threading of galvanized steel pipe, although exposing the bright metal, may not be serious. The zinc-coated surface should be anodic to the bright metal and therefore scars and threads should be adequately protected against corrosion. However, in many cases, threads on galvanized pipe have been found to be badly corroded even though the galvanizing is in good condition. The reason for this has not been apparent.

Other causes of corrosion. There are other factors that affect the galvanic potentials and current flow and therefore the rate of corrosion, such as bacterial growth, differential aeration, or acids, which will not be discussed here.

It is apparent that on city distribution systems—gas pipe lines, cable sheaths, water systems, and other metal structures—all the preceding conditions may be at work at one time, with the result that corrosion is a serious problem, especially with companies operating extensive pipe lines or lead-sheathed cables in areas where low resistance corrosive soils exist.

Factors tending to reduce galvanic corrosion. Were it not for many factors that reduce the flow of galvanic currents, corrosion of buried metals would be many times as severe as it is. Some of these factors are utilized in applying cathodic protection to reduce or stop corrosion. A fundamental knowledge of these is essential to one desiring to acquire a clear conception of how corrosion progresses or is retarded; how it can be reduced; also, how cathodic protection functions and is applied.

Among these factors are the chemical changes that take place on the surface of the metal and in the adjacent electrolyte at both the anodic and the cathodic areas. These changes on electrodes and electrolyte are caused by the action of the galvanic current flow and the result is a change in the magnitude of the current flow.

The effects are the same whether the current that flows from an anode or to a cathode is the galvanic current associated with that anode and cathode; or whether the current is stray railway current; or direct current applied intentionally from an external source.

A description of these changes follows:

At the anode, where the current flows to the electrolyte, the particles of metal may go into solution and combine with chemicals in the electrolyte resulting in a chemical change of the electrolyte, which in turn may cause a change in the potential of the anode. Usually, this change is in a direction to make the potential of the anode less negative, reducing the difference in potential between the anode and cathode.

If the chemical change in the soil at the anode forms an insoluble salt or chemical that deposits on the surface of the anodic area, it not only changes the potential of the metal to the electrolyte, but also may create a high resistance film or covering that reduces the current flow.

The aeration of the soil or amount of air carrying oxygen to the surface of the metal, movement of soil waters carrying oxygen or washing away corrosion products, chemical salts contained in the soil, type of metal, and other factors, have a considerable bearing on the chemical changes and deposits at the anode.

At the cathodic areas, current flow from the electrolyte or soil to the cathodic areas of the metal causes a chemical change in the soil adjacent to the metal, which changes the potential of the metal-to-soil, making it *more* negative. This results in a smaller difference in potential between the anodic and cathodic areas. If this change is sufficient, as it may be if the area of the cathode is small compared to the area of the anode, difference in potential between the anodic and cathodic areas may virtually disappear and hence flow of galvanic current may be minute. Usually the cathodic areas are large in comparison to the areas of the anodes, however, and the amount of galvanic current flow is not sufficient to bring about this change.

If the chemical changes form insoluble salts that deposit on the cathodic surface, a high resistance film or coating is formed, which further reduces the amount of current flow.

The amount of oxygen available at the cathodic areas is highly important. Oxygen counteracts some of the desirable chemical changes that otherwise

would change the metal-to-soil potential in the right direction. If the aeration dries out the soil, it tends to change the metal-to-soil potentials in the wrong direction tending to increase the difference in potential between anodic and cathodic areas, and increased corrosion at the anodes may result.

The changes in metal-to-soil potentials and the building up of high resistance films on the surfaces usually are referred to as polarization.

At the instant of immersion of a metal in an electrolyte, a large portion of the area has a tendency or desire to become anodes—a multitude of anodes each with a slightly different potential to the electrolyte, to each other, and to the area that may be cathodic. Current immediately begins to flow from these anodic spots and areas, but polarization of the anodic and the cathodic areas reduce the flow of current. This change in potential of the anodic and cathodic areas knocks out some of the small anodes, which become cathodes and so on until relatively few anodes may survive and remain anodes. The current flow from these remaining anodes is reduced by this polarization and change in potential of the cathodic area. Also, the remaining anodes buck each other and further reduce the current flow.

This action is progressive and quite difficult to visualize. Fig. 20 is an attempt to show the current flow after a few days in an electrolyte at which time the action has settled down. The magnitude is represented by the relative size of the arrows. The meeting of the two arrows represents the bucking effect of two anodes, which reduces the amount of current from each.

By applying a direct current from an external source, such as a rectifier, battery, or electric generator or from a more "potent" anode, such as zinc plates, that will further polarize and change the voltage of the cathodic areas and buck out the remaining anodes until all anodes become cathodes and the entire surface is then a cathode, corrosion can be completely stopped. This is referred to as cathodic protection and is explained later.

Mitigating Corrosion

Avoid use of dissimilar metals. An appreciable reduction in corrosion may be made by avoiding, so far as practical, the use of dissimilar metals electrically connected, especially in corrosive soils. Galvanized fittings and galvanized pipe in pipe line construction, galvanized conduits at stations connected to copper ground wires and rods, galvanized tower footings connected to copper wire counterpoise, etc., are sources of active corrosion when buried in corrosive soils.

Some uses of dissimilar metals are difficult to avoid, but frequently it may be practicable and economical to use dissimilar metals, and electrically insulate such metals from each other, or apply protective coating. However, where the area of the cathodic metal is very small in relation to the area of the anodic metal, the use of dissimilar metals may not be harmful, even in corrosive soils, because complete polarization of the cathodic metal area may change its potential to virtually the potential of the anodic metal and build up high resistance films so that little galvanic current may flow. Also, the small amount of remaining current leaves the anodic metal distributed over such a large surface that little noticeable corrosion results. Examples of this are the brass insert in shutoff valves used in steel service pipes, brass or bronze bearing ir valves, etc.

Where the area of the anodic metal is very small in relation to the area of the cathodic material, rapid corrosion at the anode may result because some anodic metals do not polarize easily and a relatively high galvanic current density may continue from the small anodic area, the small amount of current being too small to polarize the large cathodic area. Examples of this are galvanized caps on service pipe stubs, galvanized fittings on black iron pipes, threads cut on steel pipes, etc.

Install electrical insulation where practicable. A considerable reduction in corrosion may be accomplished by strategic installation of electrical insulating couplings, joints, bushings, etc., where it is practicable to do so. Not only is this desirable between dissimilar metals where used; it may be desirable between similar metals in many cases such as in pipe line construction to insulate tap lines from mains, old lines from new lines, services from mains, services from water systems, and new sections of pipe installed to replace corroded sections.

In many cases, especially on gas distribution systems, it may be economical to make a job of installing electrical insulating joints, couplings, and bushings on existing lines to reduce corrosion if serious, especially when maintenance, reconditioning, reconstruction, and meter replacements provide an opportunity to do so at small cost.

On new construction, extensive use of insulating materials may be highly desirable.

Apply adequate coatings. In pipe line construction, protective coatings are used extensively on steel pipe. Considering the many factors contributing to corrosion, many of which are unpredictable in advance of construction, the use of high grade coatings appears to be economical; especially on gas distribution systems when maintenance and replacement costs are high, the cost of gas lost through leakage is substantial, and there may be a gas explosion hazard.

The application of cathodic protection is simplified and in many cases made practical by the use of good coatings. On gas distribution systems, especially in densely built up areas where other metallic structures exist, the use of cathodic protection to gas pipe lines might not be practicable unless a fairly good coating is on the pipe lines, because of the extremely large currents that might be required if the pipe lines were bare.

Install cathodic protection. More and more extensive use is being made of cathodic protection to reduce or stop corrosion. It is applicable to virtually all buried metal structure.

To date, the most extensive use of cathodic protection has been on pipe lines, both cross-country and on gas distribution systems, and on lead covered electric and communication cables. Its use is being extended rapidly. It is being used on old badly corroded lines, both bare and poorly coated. It is being used on new lines to supplement even the best type of protective coatings to guard against corrosion due to holidays and future breaks in the coatings.

Because of the growing interest in use of cathodic protection, a brief explanation of fundamentals and methods of application is included.

Cathodic Protection

Fundamentals of cathodic protection. There are two commonly used methods of applying cathodic protection to buried metals:

1. By establishing a galvanic anode with a potential high enough and of large enough current capacity to neutralize (or buck out) all anodes on the metal to be protected. Zinc is used to protect cathodically steel pipe lines.

2. By forcing direct current from an external source (battery, rectifier, or electric generator) to flow through the soil or electrolyte to the metal to accomplish the same purpose.

In applying cathodic protection, the objective is to force direct current to flow through the electrolyte to all the surface of the metal to be protected, thereby eliminating the anodic areas and making the entire surface cathodic.

As explained previously when current flows from an electrolyte to a metal, a chemical change takes place that causes the potential of the metal to become more negative. This occurs in applying cathodic protection. The protective current that flows from the ground bed to the cathodic areas, and the resulting chemical changes at the

cathodic areas, make the cathode potential more negative, with the result that there is a smaller difference in potential between the cathodic areas and the anodes, and the galvanic current is reduced. The current that flows from the ground bed also tends to buck the flow of galvanic current from the anodic areas. When sufficient protective current flows to polarize completely the cathodic areas and buck out the flow of galvanic current from the anodes, no galvanic current flows and corrosion stops. In practice, additional protective current is forced to flow through the electrolyte to the metal until the entire surface collects current and the areas that were anodic become cathodic and polarized.

After complete polarization has been accomplished, it usually can be maintained and corrosion held to zero with a smaller amount of current than was required to bring about this polarization. In some soils, and under certain conditions, the cathodic protection current, if maintained, tends to build up an increased polarization film on the surface of the metal, which permits further reduction in the amount of current required.

Cathodic protection using anodic metals. In previous paragraphs, it was shown that when two metals having widely different potentials are connected in corrosive soils, the more negative metals corrode rapidly and the other metals may be protected from corrosion by the galvanic current generated.

This same principle is used in applying cathodic protection to pipe lines and other buried metals. Zinc, of high purity, is used extensively to protect steel pipe lines. The potential between steel and zinc in corrosive soils is about half a volt, with the zinc being more negative in potential, or anodic.

Zinc plates or rods are buried in soil either in groups or singly and connected as shown in Fig. 21. The amount of zinc required to generate sufficient current depends on area of exposed metal to be protected, original metal-to-soil potential of zinc and metal to be protected, character and resistivity of soil, size and shape of zinc, and the final metal-to-soil potential when polarized and protection is obtained.

The resistivity of the soil is highly important in the use of zinc, and its use may not be economical where the resistivity is several thousand ohms per centimeter cube, because of the great area of zinc required to obtain a low internal resistance (resistance through the soil between zinc and metal structure). Experiments are under way using chemicals added to the soil around the zinc to reduce the resistivity, but no conclusions have been reached.

Only high purity zinc is suitable for cathodic protection. A number of installations have been made on systems in the Southwest using rolled zinc plates. The following specifications were used.

Zinc mix No. 1—rolled plate zinc, having nominal analysis of lead 0.08 per cent; iron 0.008 per cent; cadmium 0.004 per cent; with the rest zinc.

Plates ½ in. by 12 in. by 12 in. (weight approximately 18.5 lb.) and ½ in. by 3 in. by 36 in. (weight approximately 14 lb.) are two sizes convenient to use.

Cathodic protection using external source. A large percentage of cathodic protection installations made to date use rectifiers to convert alternating current to direct current, or engine-driven generators or wind-driven generators to supply the direct current required.

In applying cathodic protection using current from an external source, it is necessary to force the current into the earth, force it through the earth into the metal to be protected, and return it to the source. Fig. 22 shows the conventional method. In general, about the same amount of current is required as would be needed from zinc anodes provided it could be distributed economically to the same extent. Usually, this is not practical on large structures, such as poorly coated pipe lines.

One of the principal difficulties is forcing the current into the earth. Contact is made with the earth by burying scrap metal, such as rails or pipe, or carbon rods. This is referred to as a ground bed. If the soil resistance is high the resistance between the ground bed and earth may be high and considerable voltage is required to force the current to flow, resulting in a high percentage of power loss.

Amount of current required for cathodic protection. The amount of current required to provide complete cathodic protection to a buried metal structure varies over an extremely wide range but in general depends on:

1. Electrical resistance of coating and area of exposed metal.
2. Soil conditions.
3. Relative extent of cathodic and anodic areas.
4. Metal-to-soil potentials of cathodic and anodic areas.
5. Distribution of cathodic protection current.
6. Bacterial activity.
7. Kind of metal in the structure.

No general rule can be given, although for preliminary estimating purposes 0.003 amp. per sq. ft. of bare surface is used frequently for iron or steel structures.

1. *Electrical resistance of coating and area of exposed or bare metal.* This is the major factor in the amount of current required. On a mile of bare 12-in. pipe line with about 18,000 sq. ft. of metal surface, 30 to 100 amp., in extreme cases 150 amp., of current might be required to provide cathodic protection. On a mile of well-coated 12-in. pipe line, a fraction of an ampere may provide protection, which indicates the important effects of a good coating.

2. *Soil conditions.* Soil resistivity, kinds of chemicals in the soil, moisture conditions, aeration, movement of soil waters, and texture of soil have important effects on the amount of current required per square foot of bare area.

3. *Relative extent of cathodic and anodic areas.* The relative size of the areas that are cathodic and anodic have a considerable bearing on the amount of current required.

It is difficult, or impossible, to determine the relative areas and usually it is not done in the field on pipe lines. However, in some cases current flow along cables and pipe lines have been measured to locate areas or sections of current pickup and current discharge.

4. *Metal-to-soil potentials of cathodic and anodic areas.* This is a definite factor in amount of current required, but this usually is not determined in the field and it is impracticable to determine this foot-by-foot along a pipe line. However, frequently the pipe-to-soil potentials at 100 ft. intervals along a pipe line are determined as an indication of corrosive areas.

5. *Distribution of cathodic protection current.* The cathodic protection current divides, part of it going to the cathodic areas and part of it to the anodic areas (or the areas that had been anodic before cathodic protection was applied). The division of current is governed largely by the relative sizes of cathodic and anodic areas; the difference in potential between the ground bed and cathodic areas, and ground bed and anodic areas; the soil resistivity, and location of ground bed with respect to cathodic and anodic areas.

In some cases, the division of current may be controlled to a large extent by proper location of the ground bed.

6. *Bacterial activity.* Some forms of bacteria apparently attack the polarization film that is built up by cathodic protection current, thereby making it more difficult to build up and maintain the polarization. When bacterial growth is encountered, considerably more current may be required to stop corrosion.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

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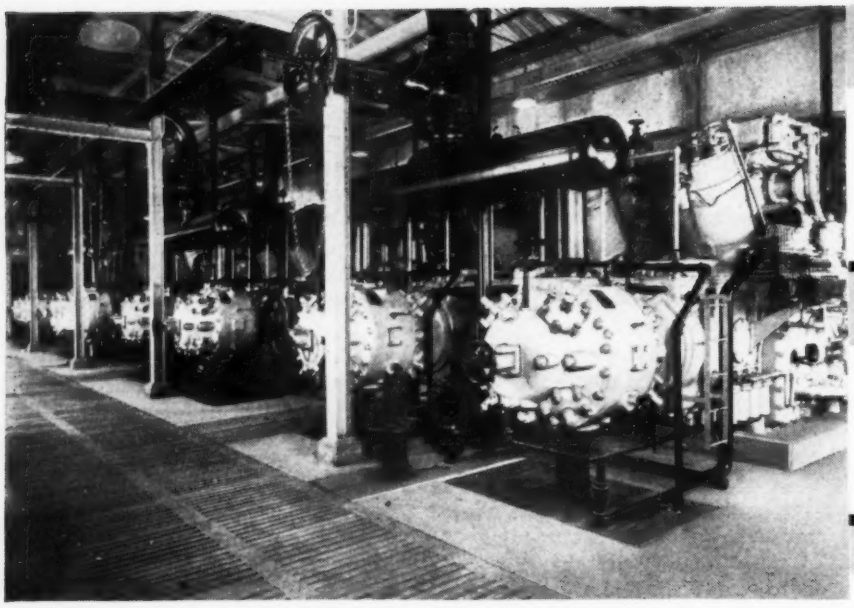

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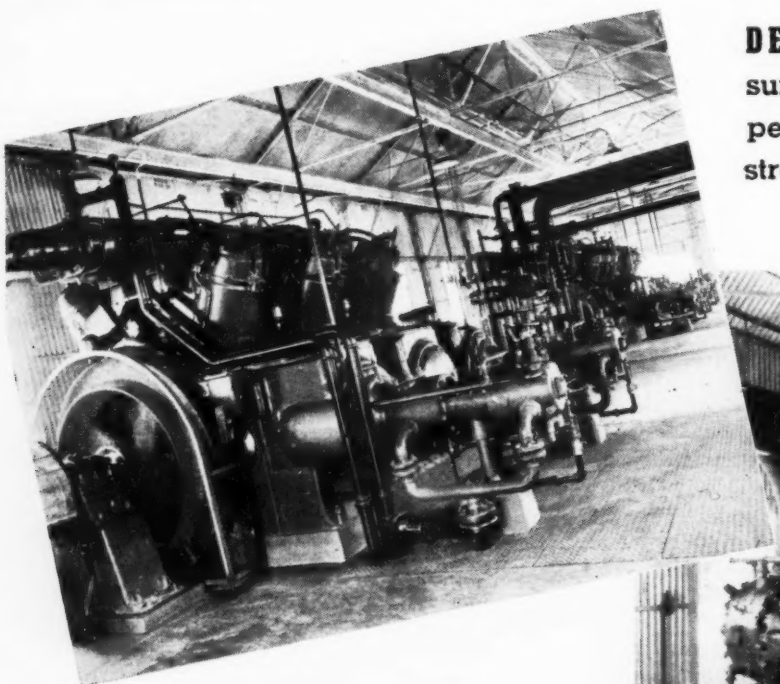

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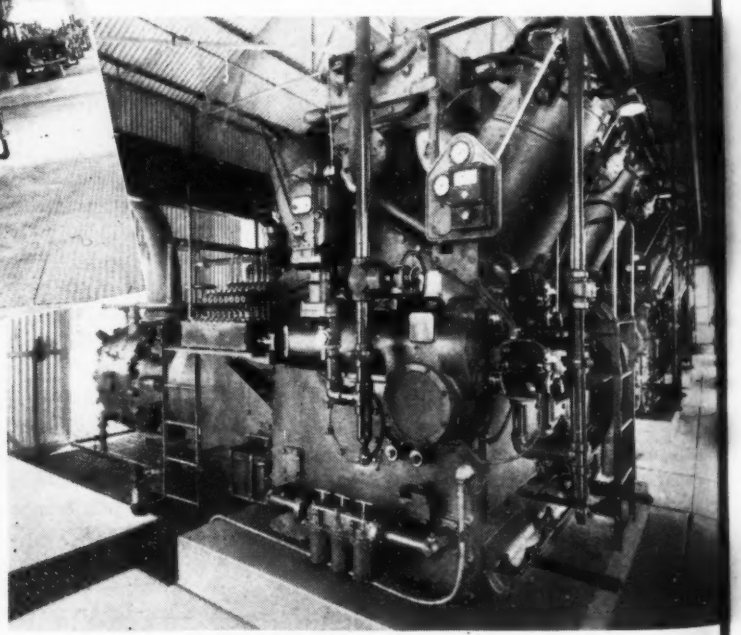

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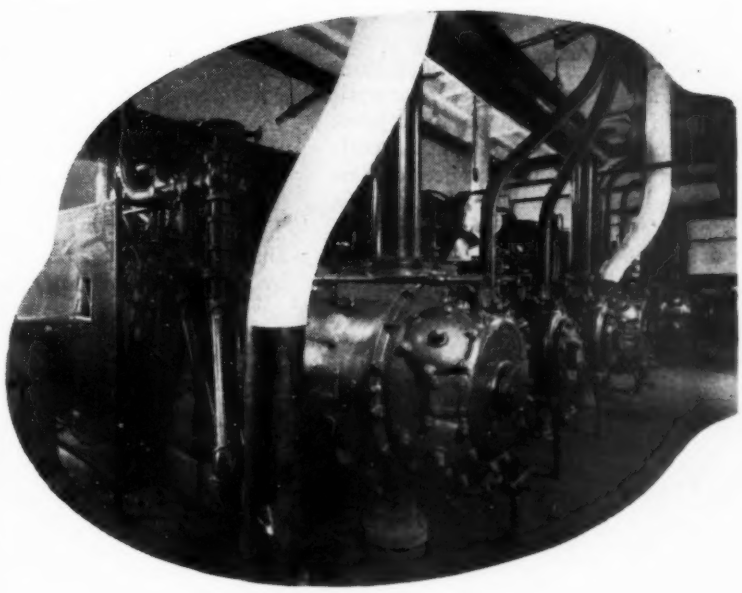

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PART 1

by F. K. Fischer, Steam Engineer
and
C. A. Meyer, Development Engineer
Westinghouse Electric and Manufacturing Company

THERE are many future uses of the gas turbine because potentially it promises greater efficiency at very high temperatures than most engines and prime movers used today. Future applications range from electric power generation to power plants for propelling airplanes, trains, and ships.

Advantages of the gas turbine cycle compared to the conventional steam system include: (1) it uses no boiler; (2) requires no water for the simple open-cycle system; (3) promises greater efficiency improvement at high temperature, and (4) has high hp-per-lb. output for short life applications. Present disadvantages include: over-optimism; fuel limitation to high grade oils instead of low grade oil and coal; lack of field experience, and need of time to complete technical developments in metallurgy and component parts of the gas turbine system.

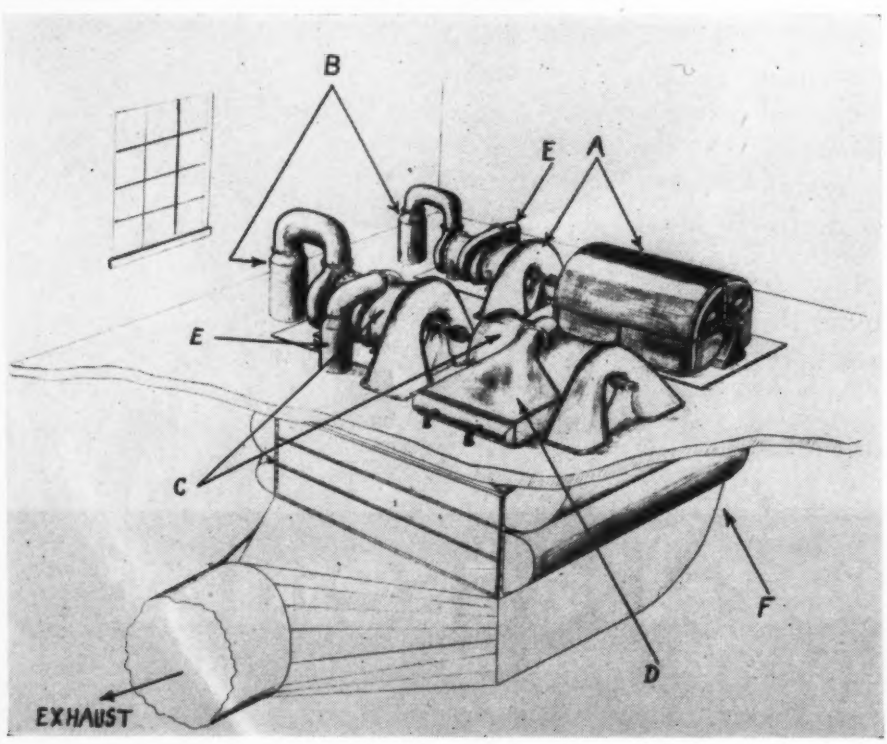
To a large degree, the future application of the gas turbine depends upon developments in the field of metallurgy, aerodynamics, combustion, and heat exchange. Present knowledge in these fields permits building and operating simple gas turbines for certain purposes. Experience with some of the simple forms of gas turbine plants has been successful and encouraging. In the post-war period, industry will benefit from the developments now being engineered for national defense. These developments will accelerate the application of gas turbine plants to new and larger fields.

Gas Turbine Is Simple

The fundamental directness of the gas turbine power cycle, in which all the hot gases of combustion are led straight to the turbine, has intrigued engineers for years. Versatile Leonardo da Vinci devised a crude version. In 1791, John Barber, an Englishman, took out the first patent on a turbine operated by gases. Since that time there has been an almost continuous stream of developments.

Progress toward a practical gas turbine power unit has been delayed because the thermal efficiency required to make it competitive with the highly developed steam cycle required: (1) operation above 1000° F; (2) a highly efficient compressor, and (3) a highly efficient turbine. Two seemingly unrelated industries have recently made important contributions to help solve these problems. Metallurgists, in developing materials for superchargers, have produced alloys that are expected to withstand at least 1200° F. continuous service at the low operating pressures encountered in gas turbine work. Aviation and wind tunnel research on airplane propellers and wings have contributed fundamental aerodynamic data on which high efficiency compressor designs are based. The research in these two industries plus the accumulated steam experience of many years have made possible the necessary high-efficiency turbine and compressor elements and solved many of the mechanical problems involved in gas turbines.

The open cycle combustion gas turbine eliminates a big and expensive step in providing power to drive generators or machinery. In its power cycle, all the hot gases of combustion go straight to the turbine, thus eliminating the steam boiler. By contrast, in the highly developed steam cycle, the fuel energy must be converted to steam, at a comparatively low temperature, before expending its energy in the turbine. In the combustion gas turbine system of power generation there are two basic cycles—the open cycle for moderate ca-



Artist's conception of a 5000-kw. open cycle gas turbine plant, using reheat, intercool, and regeneration. Two gas turbines are used, one a constant speed generator drive, the other a variable speed compressor drive. A—Constant speed gas turbine and generator; B—Combustors; C—Variable speed gas turbine and compressor; D—Intercooler; E—Reheater, combustor; F—Regenerator

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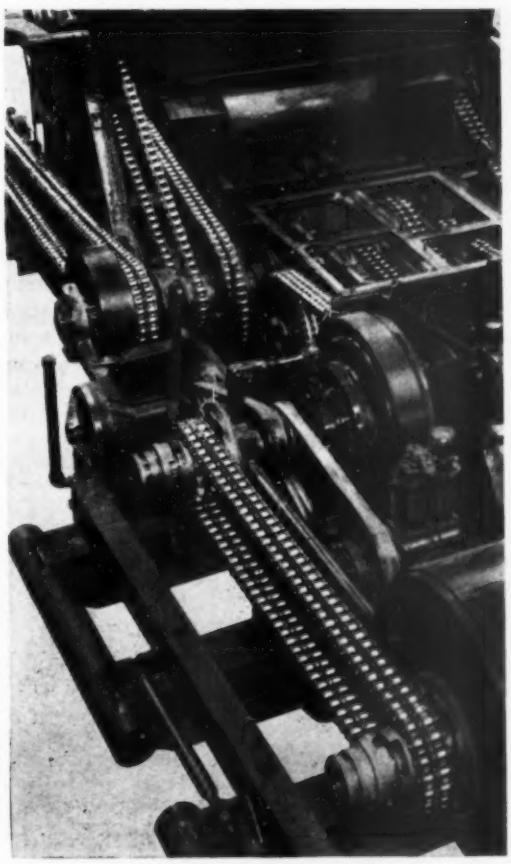

DIAMOND Roller Chain Drives on Wilson Drilling Rigs.

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pacities and the closed cycle for very large units.

The gas turbine employs the simplest power cycle known, consisting of three major elements: A compressor, a combustor, and a gas turbine. A general idea of what the elements are like are shown as longitudinal sections in true relative size in Fig. 1. The gas turbine resembles the straight reaction, non-condensing steam turbine. Gas turbine blades look more like air foil sections than reaction steam turbine blades due to the small pressure drops and large gas volume involved. The axial-flow compressor also resembles a straight reaction turbine, with the gas to be compressed passing axially through the compressor. The action of the blades in the axial flow compressor is the reverse of the action of expansion in a reaction turbine. This physically small compressor handles the large volume of gas efficiently.

The combustor is the burner in which the chemical energy of the fuel oil is converted into heat energy, by burning the fuel with sufficient excess air to obtain the desired temperature. The hot product of combustion is the gas, which, expanding to a lower pressure and temperature in the gas turbine, converts some of its heat energy into mechanical energy at the turbine shaft. The combustor is relatively small for its rate of heat release is many times that of the conventional steam boiler, which must transfer the heat through tube walls to generate steam in addition to burning fuel.

How Cycle Works

The combustion gas turbine cycle in its basic form comprises three major elements previously mentioned: Compressor, combustor, and gas turbine, plus a generator or shaft for transmitting the useful power output, and a means of starting. This simple arrangement is called the open cycle system. To start a combustion gas turbine some external means, such as a motor, is required. This is necessary because the air for combustion is supplied to the combustor by the compressor. When the unit is in operation the energy to drive the compressor comes from the expansion of the products of combustion in the gas turbine.

In the simple cycle operating at 1200°F., the products of combustion (gas) contain some 60 per cent excess air. This gas is expanded in the turbine and exhausted to the atmosphere. No intermediate fluid is used as in the steam cycle, where fuel is burned and releases chemical energy as hot products of combustion that pass through a steam boiler to generate steam for the steam turbine. The steam generator, or boiler, is the biggest single element in the steam power plant. In the gas cycle a compressor and combustor replace the boiler, resulting in a much smaller and more compact power plant. Because the simple open combustion gas cycle does not require cooling water, no steam condenser such as used in the condensing steam cycle is needed and plants may be located without regard to a suitable source of cooling water.

Although the first patent was taken out more than 150 years ago, early inventors were unsuccessful in getting units efficient enough to drive their own compressor. The cycle was perfectly sound but these early inventors lacked materials to withstand the necessary high temperature and turbines and compressors of suitable efficiency.

High Temperature Metals

Today the story is changing. Materials are capable of operating at high temperatures. The maximum temperature employed is largely a question of the length of useful life. For a life of relatively few hours, such as might be satisfactory for some military needs, temperatures of the order of 2000°F. are allowable. Heavy duty or long life applications are limited to much lower temperatures. The tremendous advances in metallurgy for the war effort will undoubtedly produce materials capable of operation at temperatures that we would not have attained for many years under a normal peacetime development.

The combustion gas turbine requires tremendous volumes of gas. The axial flow compressor, small in physical size, efficiently handles the large volumes required. Until recently the axial flow compressor was largely an unknown quantity. Today, the advancement in knowledge of proper blade shapes and research in the development of efficient air foil sections have given the designer the necessary tools to design and build highly efficient axial flow compressors.

Turbine and Compressor

In the gas turbine cycle, the useful power output depends upon obtaining relatively high turbine and compressor efficiency. The useful net output is the difference of two fairly large quantities: The total turbine output and the work consumed by the compressor in compressing the air. With the system of Fig. 2 operating at a top temperature of 1200°F., the turbine develops 3.95 units for each useful unit of power output of which 2.95 is needed to drive the compressor. A reduction of 1 per cent in the efficiency of each of these elements reduces the useful output by 7 per cent. The useful output decreases sharply as the top temperature is lowered.

In Fig. 3 the simple gas cycle thermal efficiency is plotted as a function of the pressure ratio for several turbine inlet temperatures of the combustion gas. Pressure ratio is the compressor discharge pressure divided by the compressor inlet pressure, which is 14.7 lb. per sq. in. abs. in the open cycle. The curves are based on these efficiencies: Turbine 85 per cent; compressor 84 per cent; combustor 100 per cent, and air inlet temperature of 70°F. The 750°F. curve is plotted for two different compressor efficiencies showing the effect of change in efficiency of one of the elements. A reduction in compressor efficiency of 9

Fig. 1. Left, elements of gas turbine cycle are a compressor, a combustor, and a gas turbine.

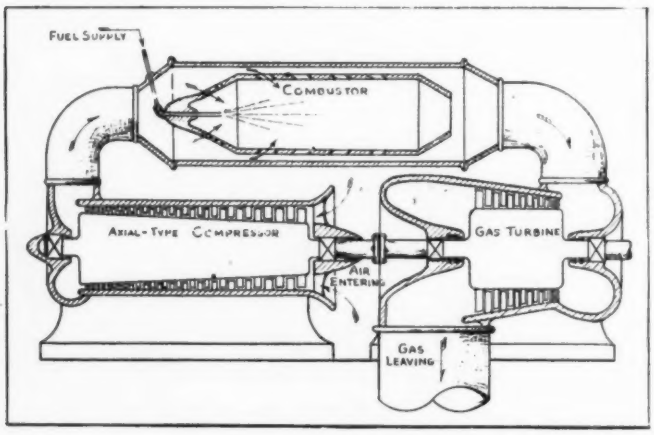
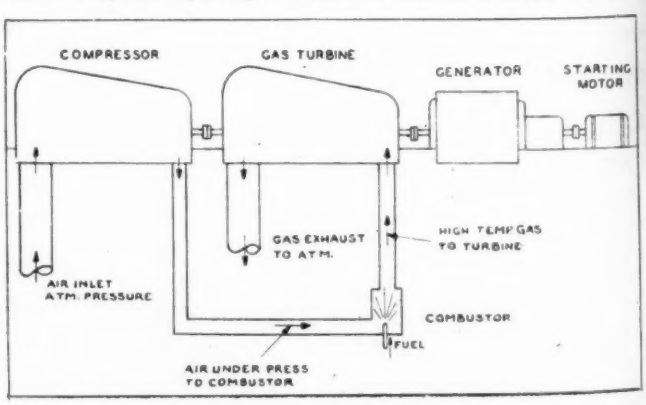
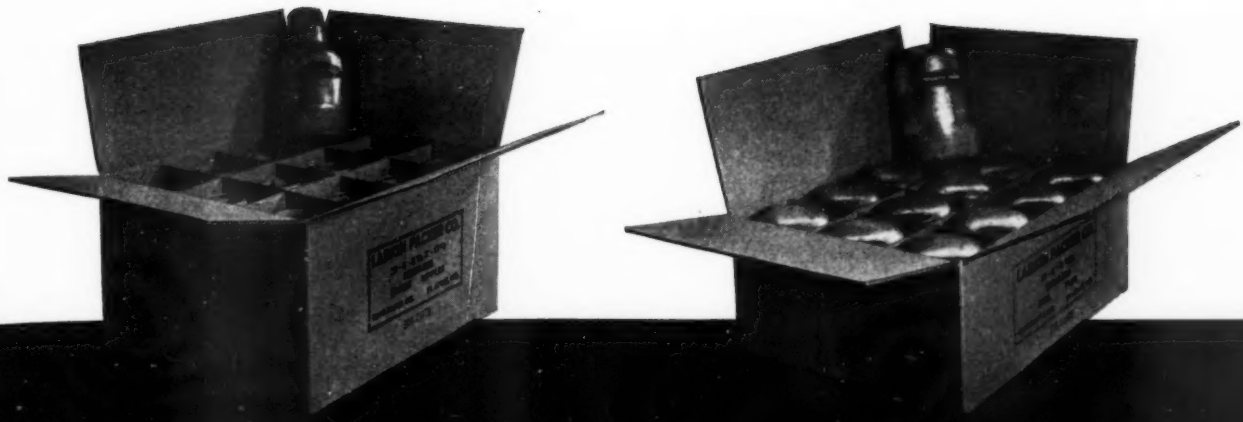


Fig. 2. Right, simple open cycle of combustion gas turbine





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per cent cuts the cycle efficiency almost in half. The relatively low pressure ratios at which maximum efficiency is obtained, about 6 for 1200°F., means that relatively low turbine inlet pressures exist in the open cycle, under 100 lb. per sq. in. abs. Low pressure results in large gas volume and relatively large turbine blade dimensions.

Engineers have been experimenting with this combustion gas cycle for many years. In Europe, because of economic conditions engineers attempted to develop it as soon as materials and compressors even remotely offered a possibility of building successful units. In this country, much of the recent development is of necessity not published because of government security reasons. There has been considerable description, however, of prewar applications in Europe. These plants are inferior in efficiency to what can be built today, but they are apparently giving satisfactory results. Interesting applications include a turbine locomotive, electric generating set, compressor drive for Velox boiler, refinery drives and airplane propulsion. Brief details are in the bibliography.

Regenerating and Intercooling

As shown in Fig. 3 the efficiency of the simple open gas cycle is low unless extremely high temperatures are used. There are three practical ways, however, of greatly improving the gas cycle efficiency. They are: Regenerating, intercooling, and reheating. The regenerating gas cycle is a cycle in which a heat exchanger (regenerator) transfers some of the heat from the relatively hot exhaust gases leaving the turbine to the air before it enters the combustor. (See Fig. 4.) Heating the air by exhaust gases reduces fuel consumption and improves the cycle efficiency. The amount of heat obtained from the exhaust gas depends on the size of the heat exchanger. This is an economic problem in which gain in efficiency is balanced against cost of heat exchanger surface. Calculations indicate that the economic size of the heat exchanger will limit the regenerating cycle, at 1200°F. inlet temperature, to approximately 75 per cent recovery of the heat available from the turbine exhaust gases. This economic size is about 0.30 cu. ft. of heat exchanger volume per kw. of capacity.

Efficiency is further improved when intercooling is added to regeneration, as shown in Fig. 5. As the name implies, intercooling removes the heat of compression from the air passing through the compressor. Water, circulating through the intercooler cools the air, and is a necessary part of the cycle. By intercooling, the compressor work is reduced because the cooler air has smaller volume. Other conditions remaining the same, one stage of intercooling will reduce the compressor work by approximately 15 per cent. This increases the portion of the turbine capacity available as useful output and improves the cycle efficiency. A large number of intercoolers is ideal but probably only a few stages will be practical.

(To be continued in an early issue)

Inspect 100-Octane Plants

A 13-member special committee of representatives of PAW, the army and navy, WPB, WMC and Defense Supplies Corporation has completed a two weeks' tour of the principal refining centers of the country to determine how 100-octane production is progressing. The object was to speed up output of vital aviation gasoline.

E. D. Cumming, PAW's director of refining, headed the group. Discussions of production problems and means of increasing output were held with managers of each plant.

Fig. 3. Effect of pressure ratio on thermal efficiency of open cycle gas turbine. Assumed efficiencies: Turbine 85 per cent, compressor 84 per cent, combustor 100 per cent. Air temperature 70°F.

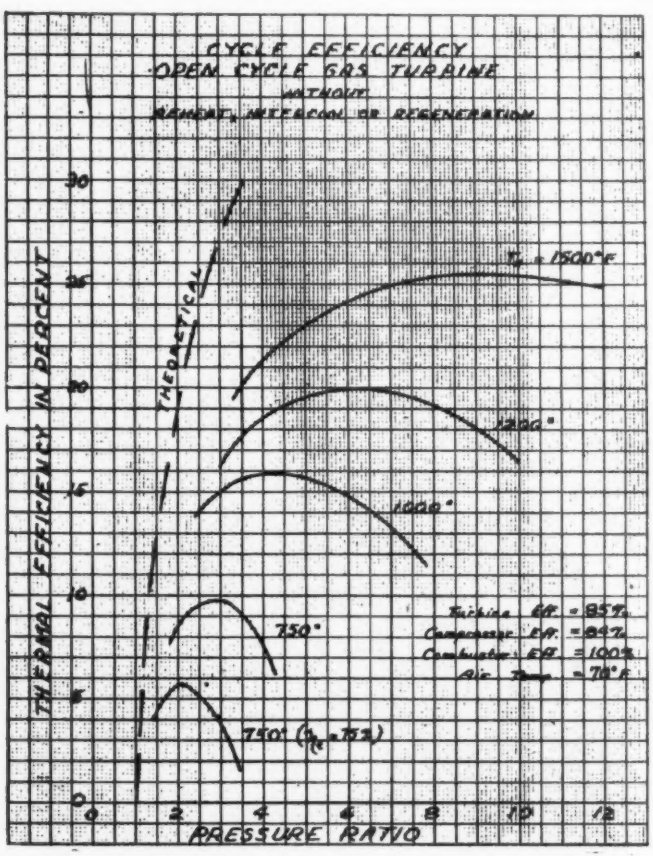
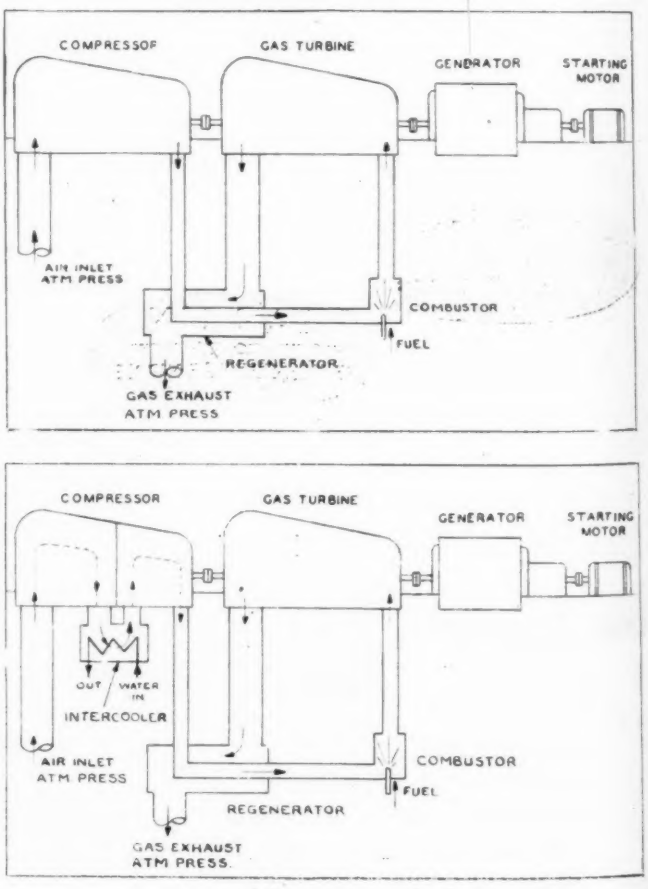


Fig. 4. Top, regeneration applied to open gas turbine cycle. Fig. 5. Bottom, intercool and regeneration for the open cycle



Shale Separator Powered By Flow of Drilling Mud

☆ Horizontal type rotary mud separator employs screened spiral drum—provides clean sample of cuttings, sand, and drilling mud

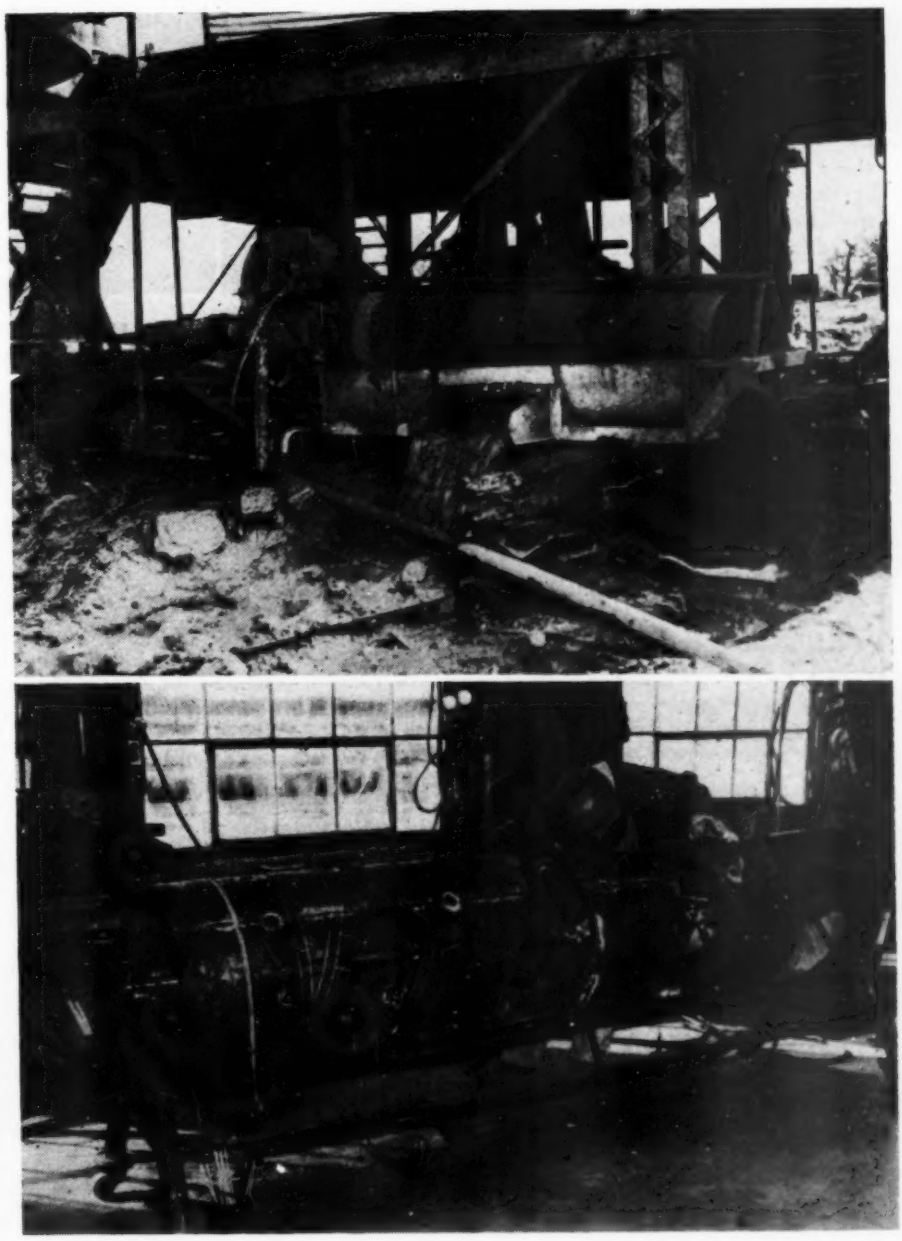
by C. C. Pryor
Associate Editor

CLEAN drilling mud is an essential item in drilling oil and gas wells. Drilling mud and its conditioning are often one of the major costs in drilling a well; however, the value of mud as a safety factor in preventing blowouts, sealing off undesirable formations, removing drill cuttings, and increasing the life of bits, drill pipe, and other critical equipment make its use essential. Numerous mechanical methods are used to separate shale and bit cuttings from the desirable portion of the mud to permit its reuse. These mechanical separators are found wherever a drilling rig is in operation.

One separator* in use today is the self-powered rotary separator, which is entirely operated by the flow of mud from the drilling well. It is easily transported from one well location to another. A large power wheel is connected directly to the mud line. The wheel is mounted one self-aligning pillow-block ball bearings and is free rolling. It is of welded construction and cannot be unbalanced. All parts are constructed to reduce wear and possibilities of damage in moving the rig, and are easily replaced.

The power wheel assembly is mounted on a heavy 4-in. by 3-in. angle-iron skid frame. The framework is of 1½-in. angle iron. The length of the separator varies depending on whether the model is for shallow, medium, or deep wells. Sizes range from 13 ft. 9 in. to 15 ft. overall length.

The flow line to the power unit depends on the size of the separator and



*Product of Thompson Tool Company.

This shaker for medium depth wells is in use on a North Texas rig. It is easily set up for operation as mud flow may be taken from either side of the mud box. In construction of the screened drum from one solid piece of metal, five hubs are included. Spiral vanes inside the drum move cuttings over entire length of the 4 screened sections to insure separation

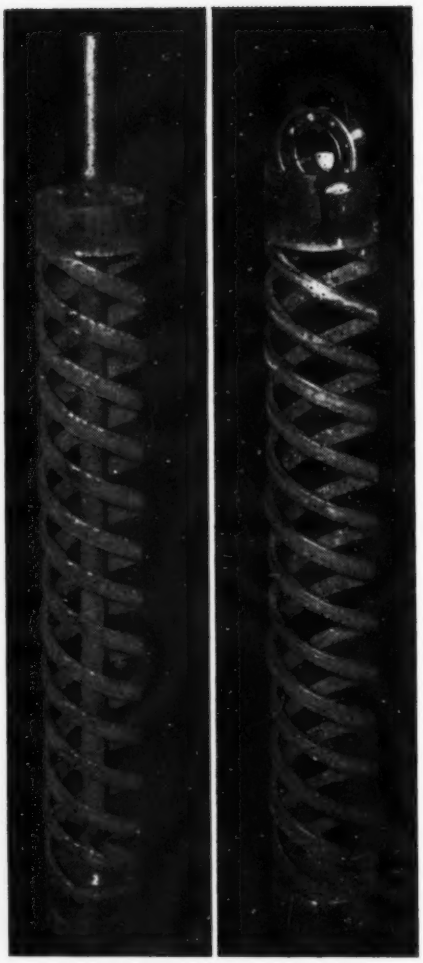
ranges from 8 in. to 10 in. diameter.

The power wheel, equipped with 8 paddles, is geared to the separating drum through bevel gears running in oilbath. A shaft from the gears turns the drum by pulleys with two positive drive B belts. An idler pulley and weight are provided for positive drive. Bevel gears from the power wheel to the drum driveshaft have a ratio of 1 to 1. The B-belt sheaves are 8 in. in diameter, providing a ratio of the power wheel to the drum of 1 to 3. The screen drum is 8 ft. long and 20 in. in diameter. It has four 18-in. by 65-in. screen sections. The screen itself is of monel or stainless steel for resistance to salt water and acid corrosion. The separator drum is equipped with five inside hubs and is of all-welded construction with a 1½-in. cold rolled steel shaft. Ball bearings are used throughout, which reduces the power requirements.

Construction Design

Design and construction of the drum is from one solid tube of metal and is cut to form spiral vanes on the inside. These vanes move the cuttings and mud the entire length of the 4 screened sections and insure complete separation of the mud and cuttings. Adjustable stretcher rods on the outside surface of the drum keep the screen tight and smooth over the areas between the vanes. The drilling fluid leaves the drum through the screened sections and the cuttings fall from the end of the drum after passing over the 4 screened sections. Sheet steel of 10 gauge is used in construction of the drum.

A spray system is provided on the main drum with strip spray nozzles that prevent the screened sections from becoming clogged with mud or shale.



Photograph showing construction of the sampling attachment drum that is spiral cut from 4-in. drill pipe

The screen is attached to the drum in 4 sections by steel clamp bands that encircle the drum. Screen sections are easily removed and new sections installed.

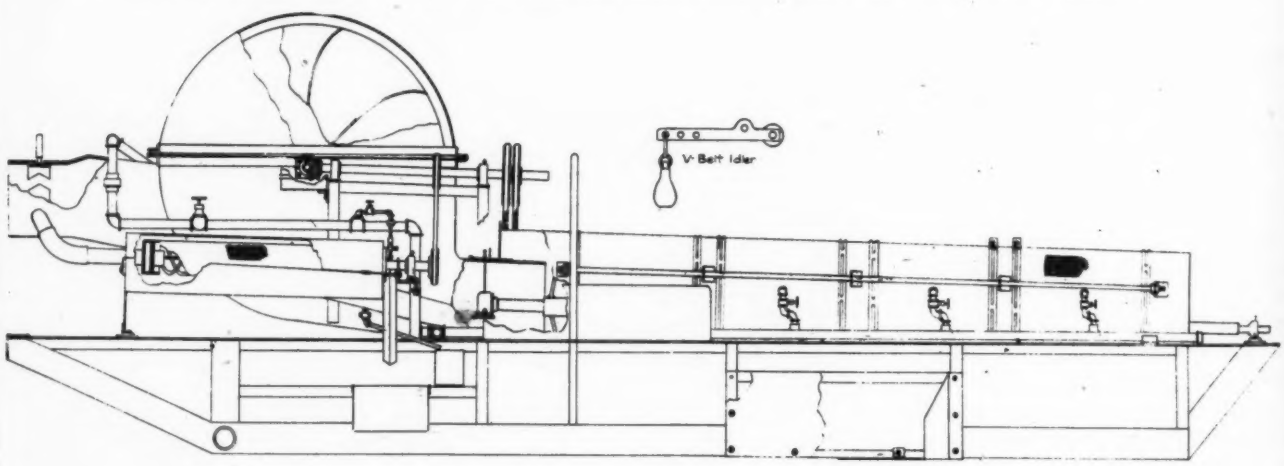
Sample Attachment

A second feature in addition to the mud flow power wheel is the sampling attachment mounted on the side of the separator below the power wheel housing. This equipment consists of a small drum that is spiral cut from 4-in. drill pipe. Screen material on the small drum is the same as that on the main drum. A 1-in. cold rolled steel shaft through the drum turns on ball bearings, enclosed and lubricated by grease cups. The screen is driven by V-belt from the power shaft of the power wheel. Flow from the large incoming mud line can be regulated by a diverter that directs a portion of the mud into the sample drum. The sample drum provides for taking a clean sample of the cuttings and also a sample of the drilling mud and sand.

This self-powered shale separator is available in three different sizes: For shallow depth rigs, medium depth rigs, and deep drilling rigs. The lightest or smallest separator for shallow or ordinary drilling is 13 ft. 9 in. long and 4 ft. 4 in. high. Angle-iron skids are 3 in. by 3 in. with 1½-in. angle iron frame. The incoming mud line is an 8-in. O.D. pipe. The overall weight of the equipment is 1400 lb. A medium or deeper depth shale separator has a heavier skid frame made of 4-in. by 3-in. angle-iron and 10-in. O. D. incoming mud pipe, a length of 14 ft. 10 in., a height of 5 ft., and a weight of 1550 lb.

The largest size shale shaker, designed for deep drilling and large volumes of mud cleaning, is 15 ft. in length and 5 ft. in height. The flow line connection is 10-in. O.D. pipe with a specially designed power wheel for greater power and speed. Weight of this separator is 1600 lb. —— ☆ ☆ ☆ ——

Sketch of the shale separator powered by mud flow. Mud enters the flow line at the right end of the separator and turns the power wheel. Power is transmitted to the screened drum by a shaft and B-belt drives. The sampling attachment is shown below the power wheel with intake from the main mud line diverter control



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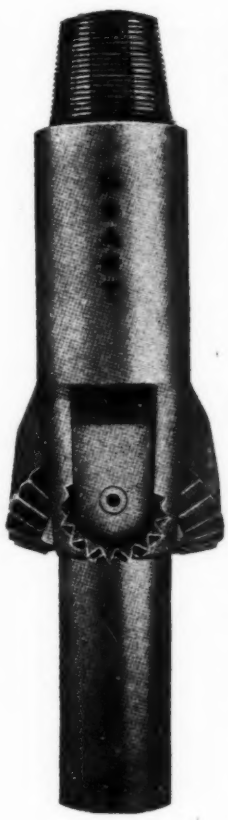

Developed to improve the usual methods of opening or enlarging holes, the GRANT "Rat-Hole" Enlarger will ream a hole out to a considerably larger diameter than that called for when an ordinary straight reamer is run.

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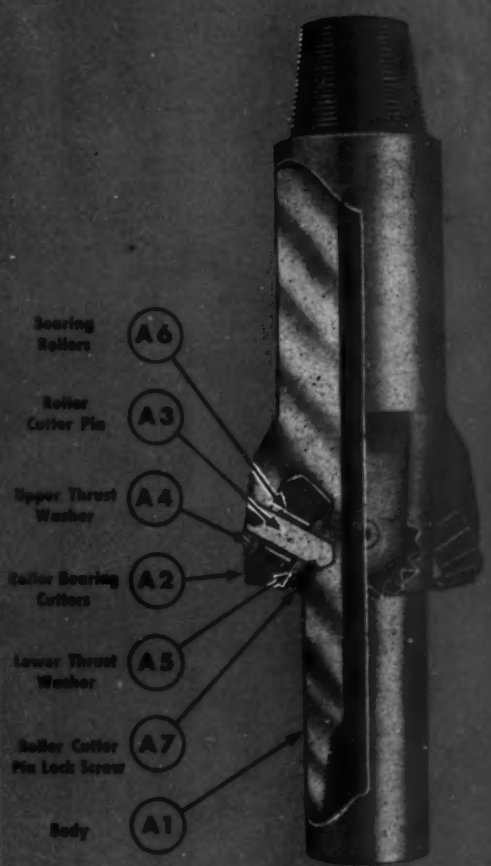
Cutters of the GRANT "Rat-Hole" Enlarger are easily replaced at the rig, as no welding is required. Roller bearing construction provides long life. Teeth are hard-faced for maximum footage and full gauge hole.

The coupon below will bring you detailed information on the "Rat-Hole" Enlarger and other GRANT Oil Tools. Mail it today.



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New Type Rig Drilling East Texas Wildcat

☆ Drawworks and rotary table are driven by VU-420 hp., 12-cylinder engines through selective transmission

PETROLEUM ENGINEER Exclusive Feature

by C. C. Pryor
Associate Editor

PROGRESS in the development of drilling rigs powered by internal-combustion engines has been great in the last few years. New designs in power transmission—engine compounding, compounding transmissions, clutches, and drawworks—have played an important role in the modern drilling rig. The term "flexibility" can now be applied to the internal-combustion engine rig as well as to the steam engine powered rig. Whereas the steam rig required boilers, water tanks and equipment, and heavy steam engines, this rig uses gas, gasoline, butane, or diesel fuel and is a highly compact unit permitting high efficiency in rigging-up, drilling, and moving to new locations. The internal-combustion engine powered rig has been developed to meet all requirements arising from the deep drilling trend of recent years.

One of the latest type modern rigs is at present drilling a projected 9500-ft. test being drilled by the Penrod Drilling Company in the south central portion of Harrison County, Texas, and is owned by the Hunt Oil Company. The well is Hunt No. 1 Bailey and Martin, J. J. Martin survey. It is the second well for the Darco area, the first being drilled two years ago to the Pettit formation at 6518 ft., where a show was encountered. If the projected depth is reached it will be the deepest in Harrison County.

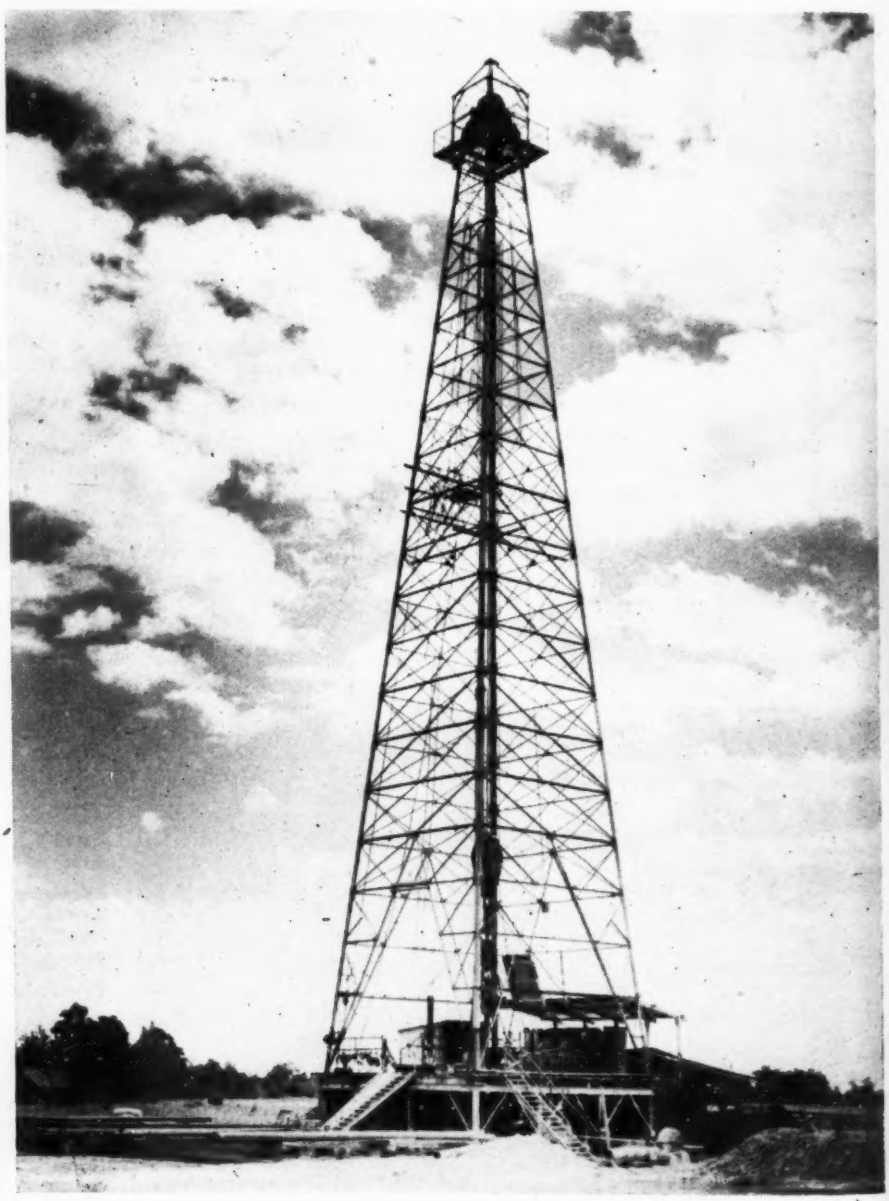
Surface casing has been set at 1600 ft. The rig is the fifth of its design to be constructed and is the second placed in operation in Texas. The first rig began operation several weeks earlier near Dumas in the Panhandle. This new rig is designed for 10,000-ft. wells with 4½-in. drill pipe and incorporates the latest designed equipment by the manufacturer[1].

Drawworks

The principal items of rig equipment are the drawworks, a three-speed forward and reverse transmission, compounding transmission, three VU-420 hp., 12-cylinder butane fuel engines, the main and auxiliary mud pumps, and the rotary table. The drawworks has six hoisting speeds, three rotary table drive speeds, two reverse speeds to the drumshaft and one reverse for the rotary table. Although the drawworks has only two speeds, in combination with the three-speed transmission, hoisting speeds are increased to six and the rotary table speeds to three. Friction clutches on the drum low, high, and rotary drives are disk-type air operated. The drum low friction clutch is a 36-in. double plate type; drum high, 30-in., and rotary 21-in. A positive splined multiple clutch is provided for the emergency drum low speed. The drum low friction and emergency clutch is outside the post bearings at the driller's position; the drum high friction clutch on the lineshaft inside the post bearings on the rotary drive side, and the rotary friction clutch is on the lineshaft outside the post bearings on the rotary drive side. The rotary table is 20½ in. in diameter.

Shafts

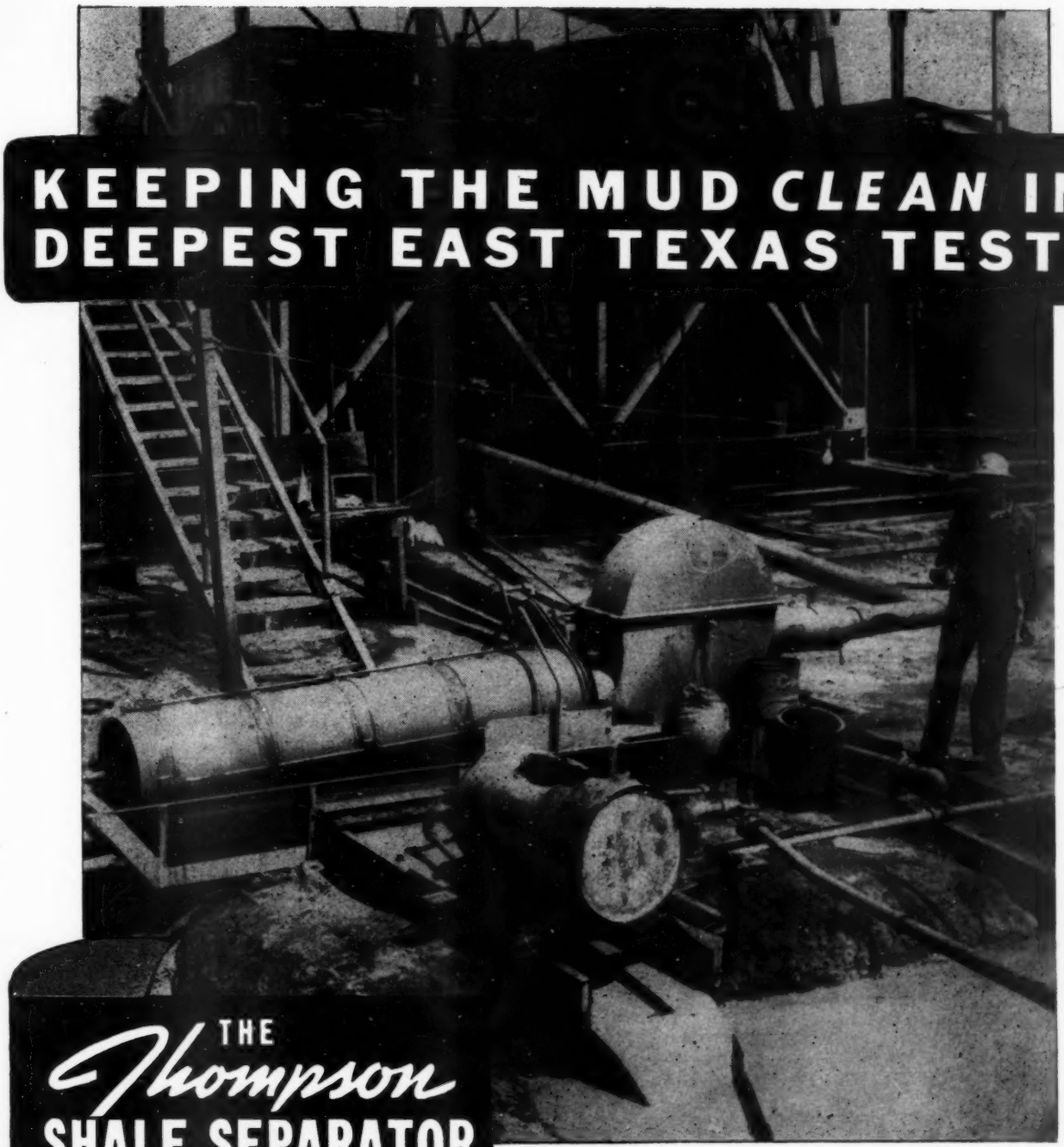
There are three main shafts, line, cat, and drum, that are mounted on self-aligning roller bearings. Drum low and catshaft drive is outside the post bearings on the driller's side. In the drum low and high friction clutches the air-



New rig in Darco area

[1]Emsco Derrick and Equipment Company—Continental Supply Company.

KEEPING THE MUD *CLEAN* IN DEEPEST EAST TEXAS TEST!



THE *Thompson* SHALE SEPARATOR AND SAMPLE MACHINE

Here is the Thompson Shale Separator doing a thorough job of cleaning mud on the Hunt No. 1 Bailey & Martin test well. The well, now down approximately 5,000 feet, will go to 9,500 feet—the deepest test well ever drilled in East Texas.

THE THOMPSON SHALE SEPARATOR is the most economical and simplest method of removing shale from mud while drilling. By thoroughly cleaning and reconditioning the drilling mud, you can reduce the wear and actually prolong the life of critical drilling equipment. It has proved so useful and essential that it is now considered standard equipment with many major oil companies and independent drilling operators. Operates entirely from the flow of mud—does not require any other means of motivation power. This, in itself, is a highly desirable feature, since there are no motors or other auxiliary units to maintain, repair, or replace. Nothing to get out of order that can't be repaired easily and quickly.

THE SAMPLE MACHINE—A boon to drilling operators and geologists alike—a sample machine which provides accurate foot-by-foot cuttings. Mounted on side of separator—easily accessible. Often declared to be worth the entire cost of machine!

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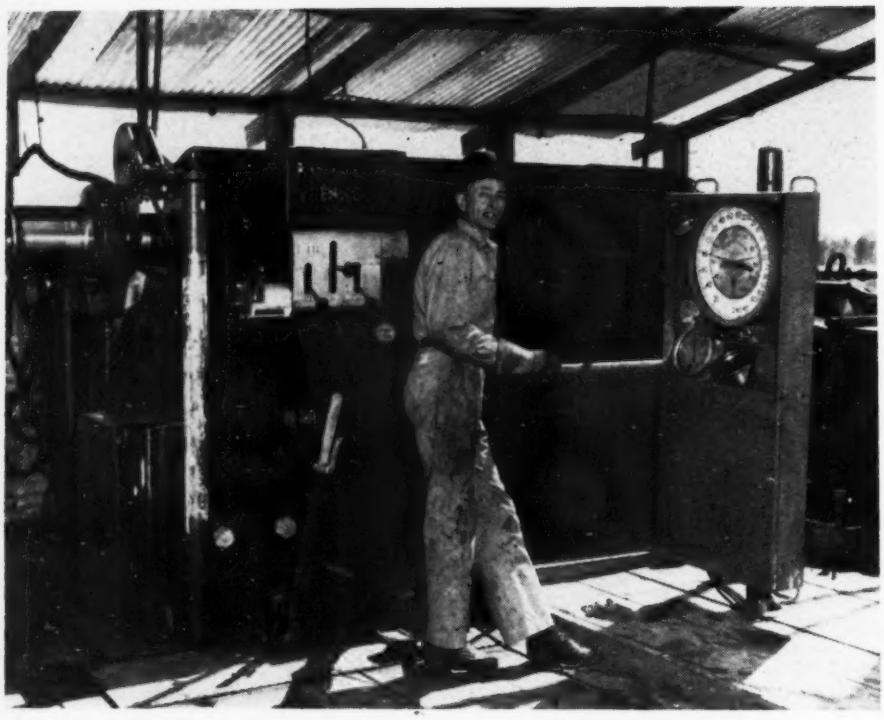
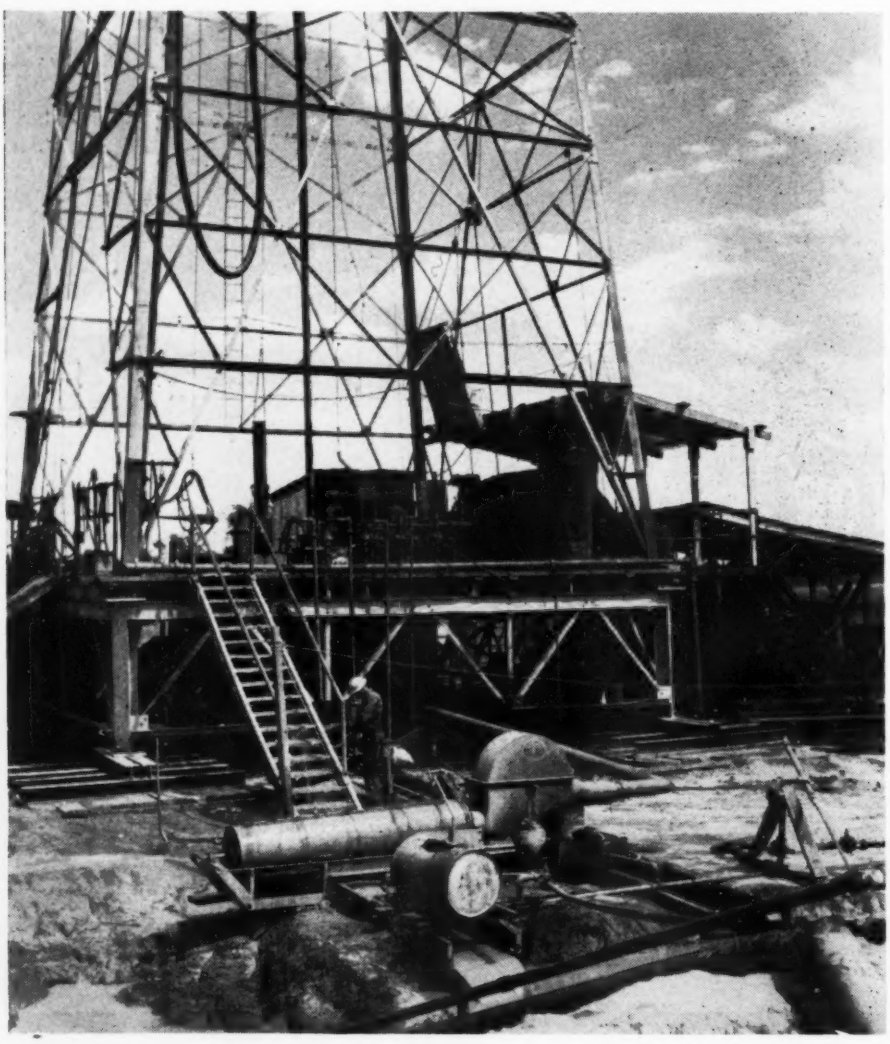
KEEPS DRILLING MUD *CLEAN* — PROVIDES *TRUE SAMPLES* OF CUTTINGS



J. F. Garrison, driller with 25 years' service with Hunt Oil Company, at the controls of the drawworks

Side view of the rig with shale separator driven by mud flow in the foreground



operated mechanism is built integral with the clutch. During drilling a gear tooth clutch on the lineshaft is disengaged and permits the catshaft and the drum low drive to remain stationary. Low, high, and lineshaft drive chains are 2½-in. pitch, double width and the catshaft and rotary idler drive have 2½-in. pitch single width chains. Sprockets are machine cut and the teeth flame-hardened. Low drum clutch, lineshaft drive, drum high clutch, rotary clutch, and drum rotary idler sprockets are mounted on roller bearings to insure free running and maintain chain alignment. The rotary drive sprocket is bolted and keyed to the drum idler sprocket. A guard separates the lineshaft to the drum idler drive from the rotary table drive sprocket preventing mud from entering the inside idler drive from the rotary chain.

Brakes

The hydromatic brake on the drawworks is cradle mounted on the rotary table drive side. It is equipped with a multiple jaw clutch mounted on the brakeshaft, which engages with jaws on the end of the drumshaft to engage the brake. The clutch is operated by a hand shifter.

The length of the plain drum in the drawworks is 40 in. and diameter is 25 in. The tapered drumshaft strength has a 3 to 1 factor and 60,400-lb. line pull. Eight lines were being used on the blocks with four layers on the drum. Capacity of the drum using 1⅛-in. line is 2800 ft.

Brakes on the drawworks are full wrap, self-energizing, and have 325 degrees lining contact on the rims with a multiplying leverage of 54 to 1. Brake rims, 9½ in. wide and 46 in. in diameter, are press forged steel and are bolted between two flanges in double shear. The rims are individually water cooled by a forced circulating system built into the drawworks and controlled from the driller's position. Brake toggles are equipped with roller bearings. There is an equalizer on the live end of each band, which has 10 brake blocks 1¼ in. by 9 in. by 12 in. A friction locking device on the brake lever permits setting the brake to feed off smoothly or to hold a load when the driller is away from his post.

Driller's Controls

All controls are conveniently arranged at the driller's position with one hand lever operating the drum low and high clutches, one for the rotary friction clutch, and one for the master clutch and brake. Variable pressure valves are used to control the friction clutch operations. The valves are hand operated and are used in conjunction with an independent foot operated throttle. Com-

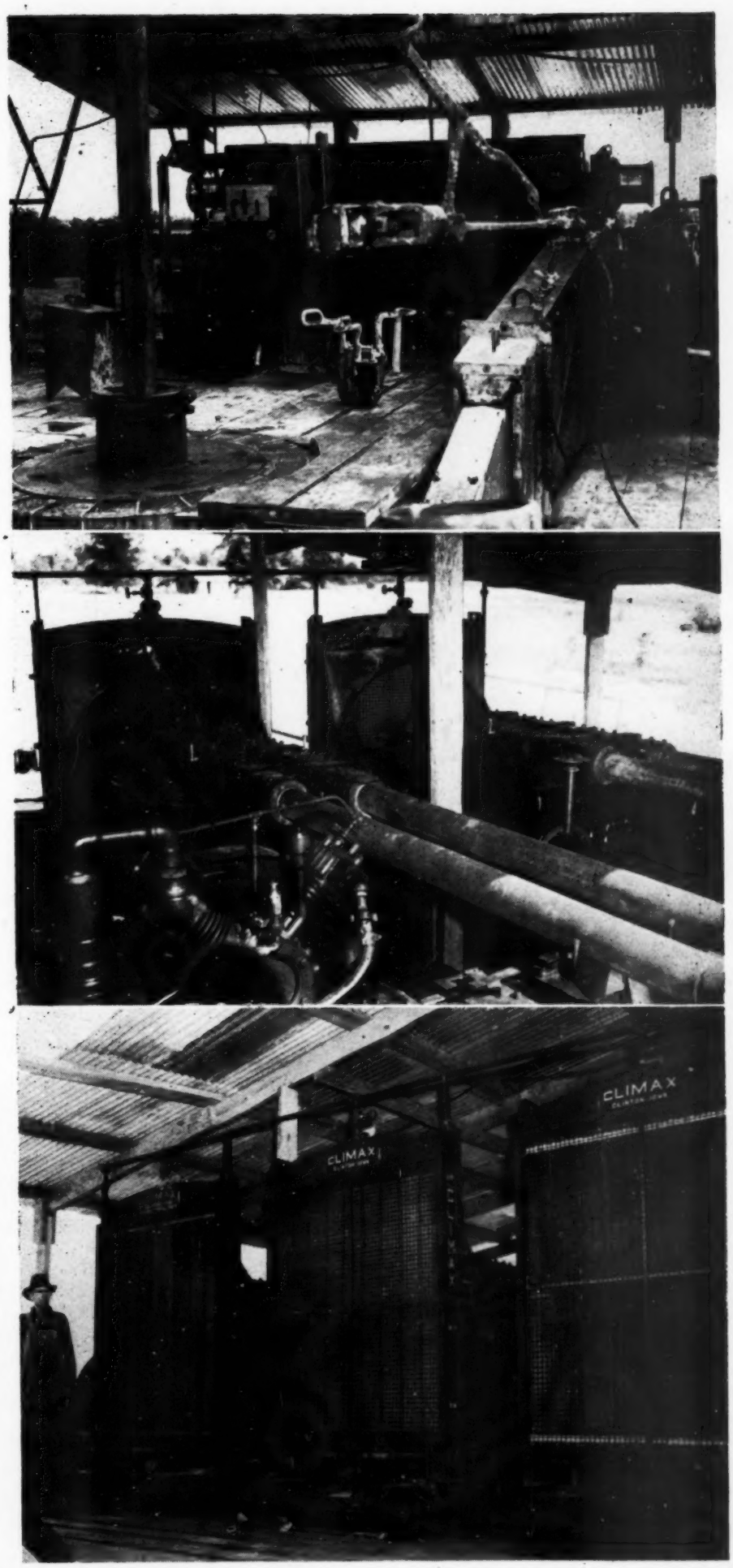
pressed air for clutch operation is supplied by a two-stage, air cooled V-type compressor driven from the compounding transmission. Air is stored in a container 22 in. by 72 in. at 100-lb. pressure. In addition to the three lever-controlled valves described above, a fourth hand lever is used to control the two clutches in the transmission and a foot pedal controls the low speed emergency clutch, which is for a low speed positive drive and is used only for extreme load or air supply failure. Control of the cathead is by a foot pedal. A safety factor is provided in operation of the friction clutches and should the air supply fail, friction clutches will disengage.

Other controls at the driller's position include hand and foot throttles for the engines and air pressure gauges. The weight indicator is mounted directly in front of the drawworks within a few feet of the driller's position. Hand and foot levers hooked together control the first engine and the second and third engines can be controlled by hand independent of the first engine, or if desired the second engine can be connected with the first engine when all the power is required for the drawworks. By means of the foot throttle the driller can hold the brake and hand operate the lever to engage the friction clutches. The master disk clutch and neutral brake on the compounding transmission forward engine shaft is primarily for selection of speeds on the three forward and one reverse selective transmission. A visual indicator at the driller's position provides for shifting the transmission clutches at the proper speeds to avoid fast engaging.

Selective Transmission

The selective transmission is located behind the drawworks on a substructure panel approximately 5 ft. below the derrick floor. It is an independent unit between the compounding transmission and the drawworks. Drives from the compounding transmission and the drawworks are in oil tight guards, flood lubricated. The substructure panel can be arranged on the same level as the drawworks or stair stepped as shown in the illustrations, which is desirable on high derrick-substructures to allow the engines, compounding transmission, and pumps to be on the ground level. All shafts in the selective transmission are mounted on self-aligning roller bear-

(Continued on Page 80)

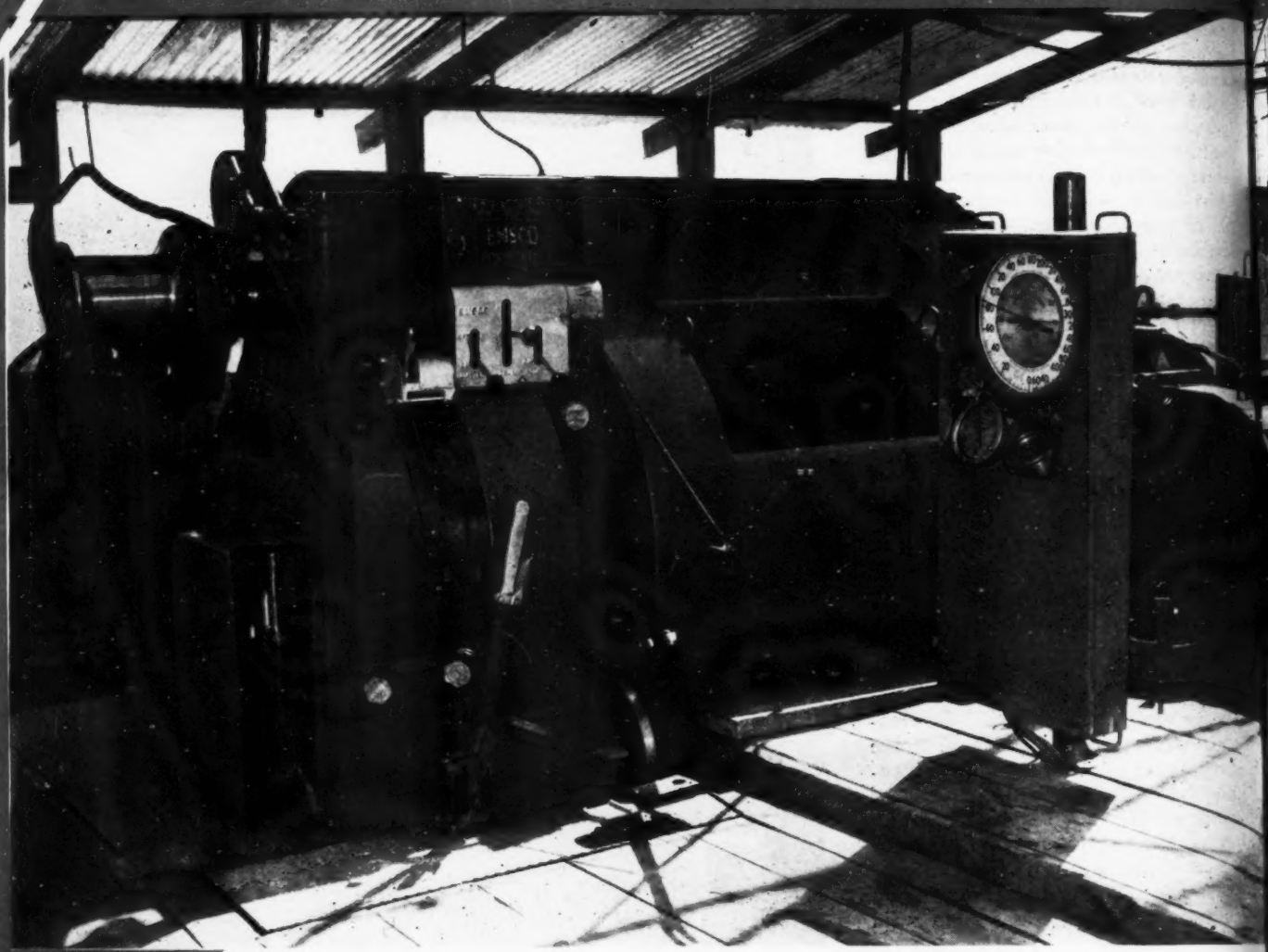


Top—Drawworks and rotary table of the new rig from the rotary side

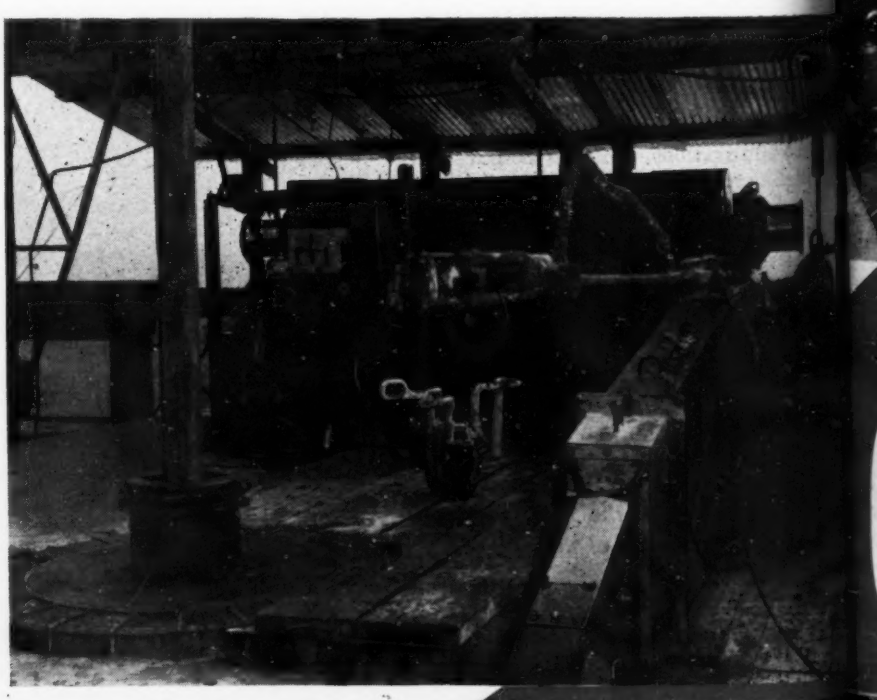
Center—Two of the VU-420 hp. butane engines that power the rig. The compressor for the air actuated clutches is in the foreground

Bottom—Radiators of the engines

Another EMSCO J-100

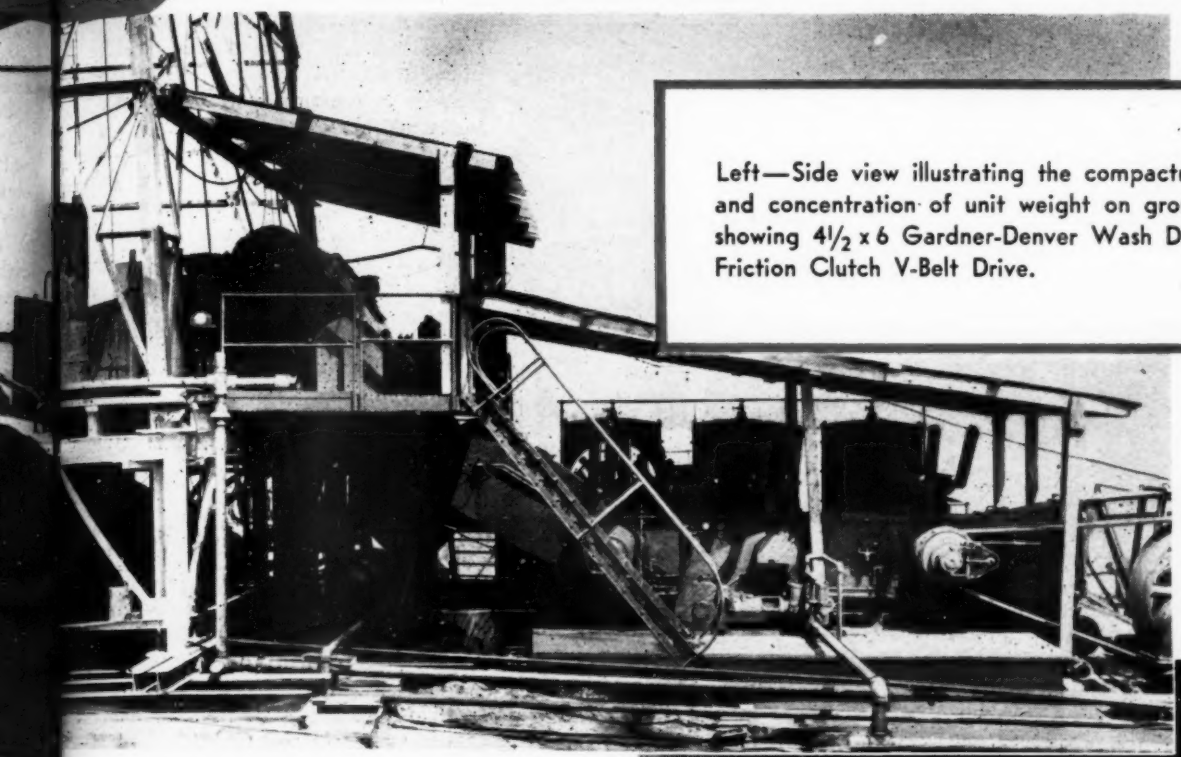


Above—View from the driller's side of the Drawworks, showing the Water Cooled Cathead and Instrument Panel. Entire Unit controlled by Variable Air Pressure Control Valves at Driller's Position.



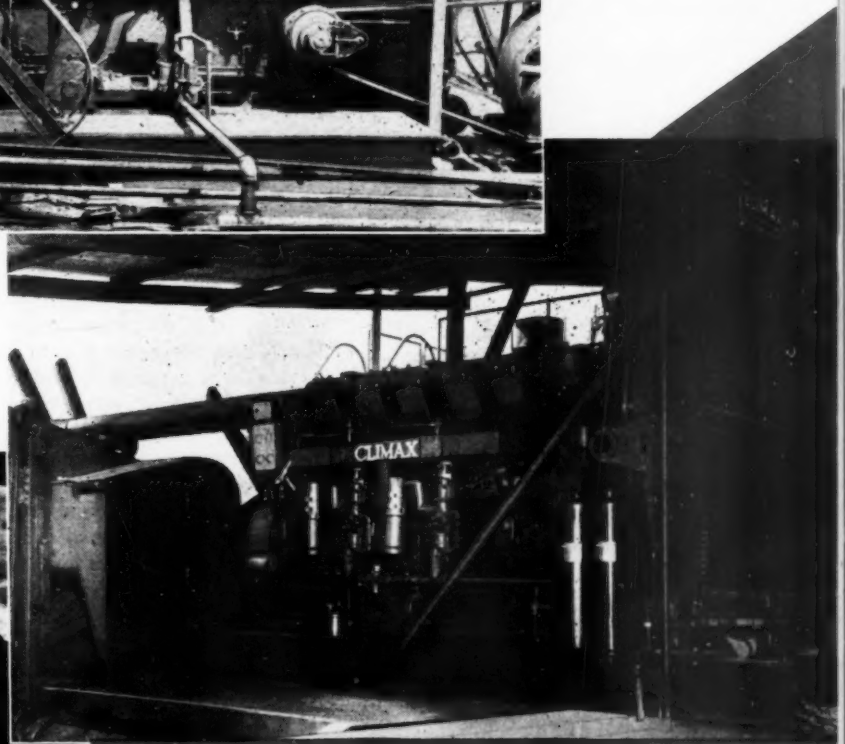
Right—Front view of Drawworks showing Hydromatic Package with Fluid Level Control and Totally Enclosed Telescopic Pressure Lubricated Rotary Chain Guard

POWER DRILLING RIG



Left—Side view illustrating the compactness of the Rig and concentration of unit weight on ground level. Also showing 4½ x 6 Gardner-Denver Wash Down Pump and Friction Clutch V-Belt Drive.

Below—Opposite to Radiator view of Climax VU-420 Drilling Power Units, with Gardner-Denver ADR 6¼ x 3½ x 4 Compressor for Air System.



Above—Side view of one of the 3 VU-420 (420 H.P. @ 1100 R.P.M.) Climax Drilling Power Units.

★ ★ ★

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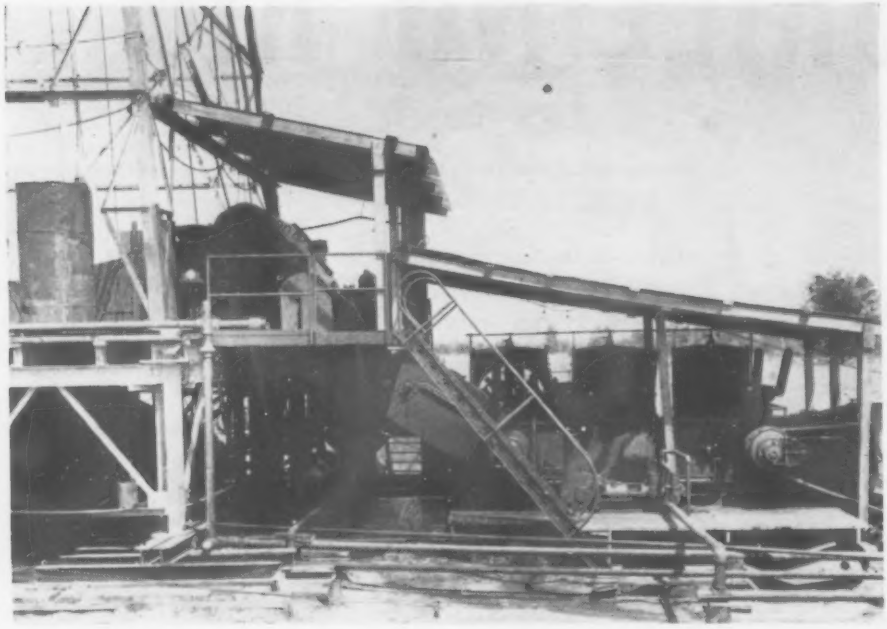

Selective transmission is mounted on a sub-panel below the drawworks and above the compounding transmission

(Continued from Page 77)

ings. The input shaft sprocket has 72 teeth and use 1½-in. quadruple chain. Chains for the low, second, and high speed drives are 2-in. pitch triple strand chain, whereas the reverse drive is obtained through herringbone gears.

The engine compounding transmission is designed for use with three engines with a combined power output of approximately 1250 hp. Four shafts, three for the engines and one for the inside mud pump, are provided in this transmission. An extension from the rear engine shaft is used to drive the outside mud pump, 20 V-belts being used for each pump drive through friction clutches controlled by air pressure from the driller's position. The mud pumps are two 7¼-in. by 18-in. 357-hp. units. A master friction clutch is mounted on the first engine shaft to control the power output to the selective transmission. The neutral brake is combined with the clutch control to aid in speed selection. This clutch is also controlled from the driller's position.

Lubrication to the main drive chains is provided by two oil pumps arranged so that they can be removed from the outside of the case. Drive chains are on the side of the case out of the path of the main drive chains. The oil is pumped from the strainer and reaches the sprockets and chains under pressure.

Among the improvements of design and construction in this compounding transmission are: The gear tooth clutches on the compounding drives, alemite lubrication to all shaft main bearings, roller-type bearings alemite lubricated, and an enclosed and protected oil strainer in case and main drive chain breaks. The engine drive couplings are 4½ in. self-aligning and permit complete shaft assemblies to be removed as a unit from the case without removal of other parts from the shaft.

Engines

The three V-12 (60°) 4-cycle engines operating on butane that power the drawworks develop a maximum of 420 hp. at 1100 r.p.m.—a total of 1260 hp. These engines can be operated with natural gas or gasoline. The compact design of the engines provides light weight and short overall length. The crankcase is of heavy one-piece construction ribbed for strength, and the seven-bearing crankshaft is carried in precision type steel-back babbitt-lined bearings. Cylinders are cast in pairs from close-grained cast iron and have wet cylinder sleeves to simplify maintenance and lengthen operating life and economy. Pistons are cast from aluminum alloy ribbed and fitted with five rings. Piston pins are of the full floating type. Bore and stroke are 7 in. and 7 in., respectively.

Valve rocker arms, push rods, and springs are fully enclosed for protection and are pressure lubricated. The overhead valves have inserted valve seats. Full pressure lubrication by a positive driven gear pump supplies oil from the 30-gal. oil sump at about 30-lb. pressure to all moving parts. Oil is kept clean by filters.

The engines are equipped with special carburetion chambers for high horsepower output with low fuel consumption. Four single 2-in. carburetors are used with diaphragm-type pumps. With dual ignition each cylinder has two spark plugs for greater ignition flame and dependability should one plug fail. Design of the engines permits them to operate over a wide range of speeds without encountering criticals. A centrifugal fly ball type governor running on anti-friction bearings provides speed control adequate for normal service. Hydraulic governors can be used for extremely close speed regulation. Cooling water passages in the engines are deep and widely spaced around the cylinder heads and valves. Cooling water enters the cylinder block where the heat is greatest, thus maintaining uniform temperatures. The water circulation is provided by a large circulating pump of 200-gal. capacity through the engines and large radiators that are assembled in nine full-length sections per radiator.

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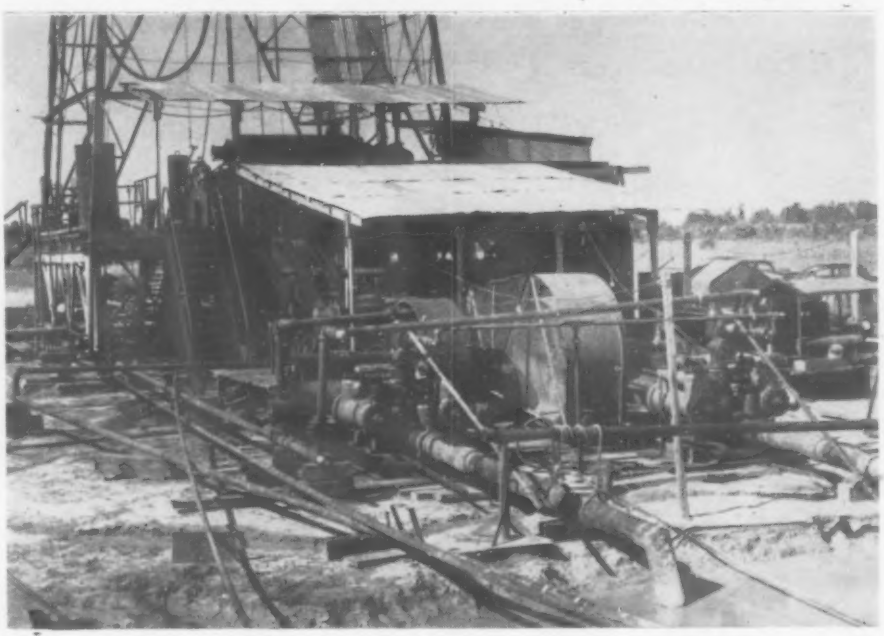
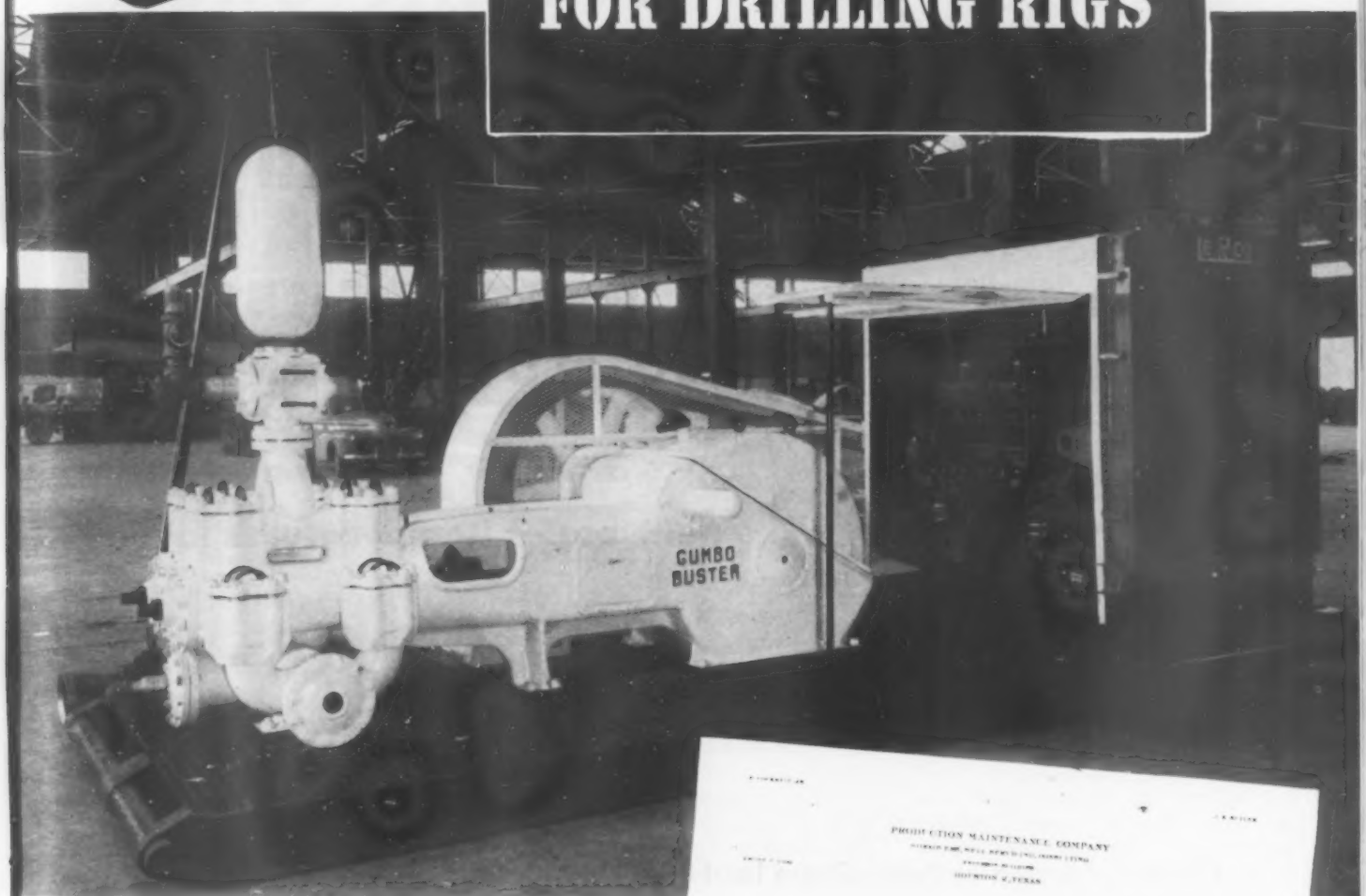
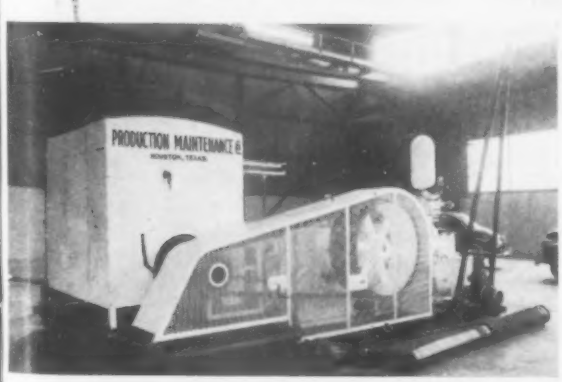


Rear of rig showing mud pumps and suction lines

LE ROI

DEPENDABLE POWER FOR DRILLING RIGS





PRODUCTION MAINTENANCE COMPANY

April 14th, 1944.

Southern Engine & Pump Co.,
900 St. Charles Street,
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Gentlemen:

We would like to take this opportunity to tell you of the performance of the LeRoi 8XIV engine which we recently purchased from you. As you know, this engine was unitized as a mud pump assembly with a 7-1/2"x14" 225 HP gear end pump. This pump unit is used primarily on deep workover and deepening jobs where high operating pressures are encountered, and is now being used in deepening a well from 7900' to 8650' using 2-7/8" drillpipe inside of 7" casing set at 7900 feet. The pump unit operates at 1700# pressure while drilling. The LeRoi engine takes the load right in its stride and is making an excellent unit. This is our first large LeRoi engine and we have high hopes for its operation.

Workover Rigs normally have just one mud pump on the job. Therefore these units must be absolutely dependable.

Very truly yours,
PRODUCTION MAINTENANCE CO.,
By B. Cockrell Jr
President

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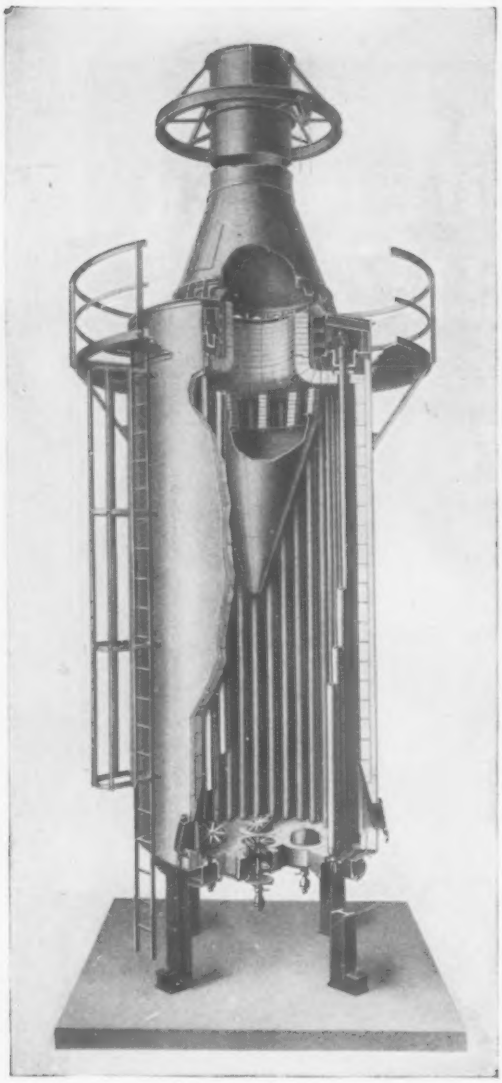

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Annual
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1944

TCC and Houdry Fixed-Base Processes

PETROLEUM ENGINEER Exclusive Feature

☆ High octane gasoline manufactured by these two major catalytic cracking processes

by T. B. Prickett and R. H. Newton
Houdry Process Corporation

THE catalytic cracking of petroleum is one of those absurdly simple processes that has required great engineering ingenuity to expand into a commercially profitable operation. Although the chemical reactions involved are complex and not entirely understood, the process itself is simple—the passage of oil vapors over a solid adsorbent catalyst with the heavy molecules broken into gasoline of high octane number, coke, and gases. Many substances are known to catalyze the reaction. Among them are activated natural clays, natural bauxites, and numerous synthetic gels, such as silica-alumina. The general reaction attracted the attention of E. J. Houdry in France in the early 1920's, when he was searching for a better fuel for automobiles. This was the beginning of the long research and development program required to bring the process to commercial success.

Today, Houdry Process Corporation is concerned with two major catalytic cracking processes. Although these two processes, the thermofor catalytic cracking and Houdry fixed-bed processes, do not resemble each other from the overall engineering viewpoint, they are both designed to accomplish the same result, namely to produce high octane gasoline from heavier oils or to treat gasoline for octane and stability improvement. Both are based on the same fundamental principles accumulated from years of research, development, and commercial experience in catalytic treatment of hydrocarbons. Although the TCC process in itself is comparatively new, those responsible for its development were able to approach their problems with years of catalytic research, development, and commercial background.

Contrasted with the simplicity of the basic process is the complexity of the commercial units in which it is carried out. For this reason, one extremely important factor involved in the successful commercialization of a catalytic process is a thorough knowledge and appreciation of the importance of detail. It is difficult to conceive a successful process if this factor has not been recognized and given proper consideration.

Basic Catalytic Reaction

The basic catalytic reaction is generally conducted at a temperature between 800 and 1000° F. and at pressures varying from atmospheric to 50 lb. per sq. in. In some operations, steam is added to the charge to lower the partial pressure of the oil vapors, in order to prevent condensation of oil in certain portions of the equipment, as one of the factors controlling the reactions, and as a regulator on the extent of carbon deposit.

The rate of oil flow is in the range of from one to three liquid volumes per volume of catalyst per hour. As the basic reaction proceeds, coke is formed as a deposit on the catalyst and the catalyst becomes less active. It is then necessary to restore the original activity of the catalyst, which is done through a step known as regeneration, which step comprises burning of the carbon deposit through the use of air.

The regeneration is possibly the most important single step in the process and as catalytic cracking has developed, has been accomplished by several ingenious means. The first method was to use a fixed catalyst bed and alternately pass oil vapors through this bed to conduct the cracking operation and then pass air through the bed to effect the reactivation of the catalyst. The Houdry fixed-bed process was the earliest commercial process and employs this principle, utilizing an integrated valve control to effect the cyclic operations necessary. Another principle that has been commercially developed is that of moving both the catalyst and the vapors. This principle is employed in the TCC process, which has reached commercial operations during the last year. In this process, catalyst in pellet or bead form is moved through the reactor and the

regeneration kiln where the reactions and the reactivation are effected, means of transport being specially designed bucket elevators coupled with gravity flow.

In addition to providing for the intermittent use of the catalyst, a major problem has been that of thermal balance in the units. The cracking reaction is endothermic whereas the combustion of the carbonaceous deposit is, of course, exothermic; however over the entire cycle of cracking and regeneration a tremendous quantity of heat is evolved and must be removed from a commercial plant. The quantity of heat to be removed varies with the type of charging stock and degree of cracking and necessitates that commercial units be quite flexible in their heat removing capacity.

Although the catalysts used are quite rugged, they are nevertheless damaged by high temperatures and one of the essential factors in plant design is that precise temperature control be obtained during regeneration. In the TCC process the water circulates through heat-exchange pipes located in the regeneration kiln, thus removing heat through direct generation of steam at high pressure. This is accomplished in the Houdry fixed-bed process by limiting the amount of carbon deposited on the catalyst and by removing the excess heat of regeneration by means of a cooling medium for which a molten salt is employed. The heat removed by the salt is converted into useful energy through generation of steam in a boiler separated from the catalytic section of the plant.

In order to provide the active, coke-free catalyst required for satisfactory cracking, the amount of carbon that is allowed to accumulate on it before regeneration is small and thus, if satisfactory conversion is to be realized, a short exposure of catalyst to oil is necessary. This requires a frequent changing of the cyclic values in the fixed-bed process, or a rapid turnover of the catalyst in the TCC process.

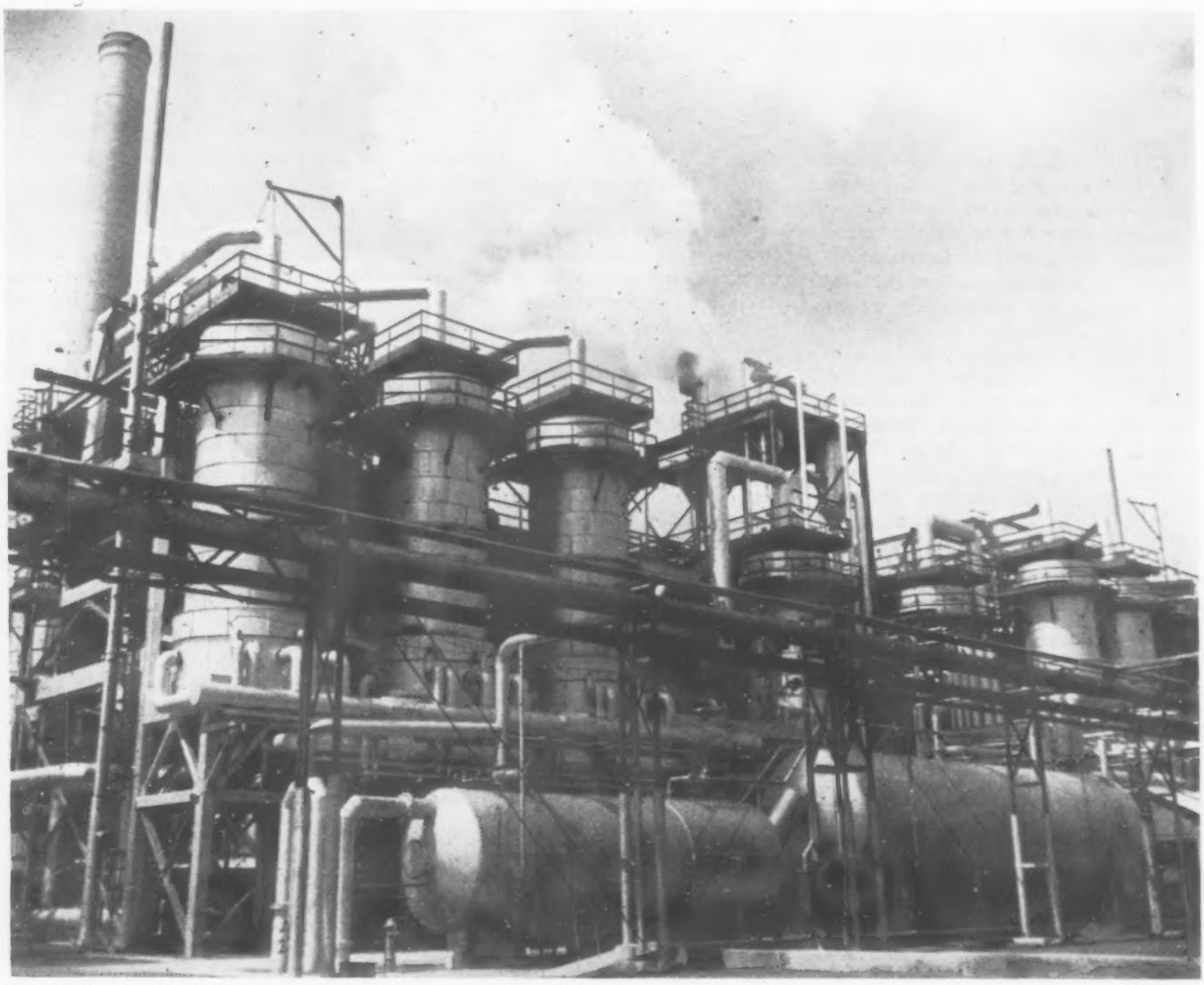
Regeneration

In the fixed-bed process, regeneration is effected by the use of air at 45-lb. pressure. For reasons of economy, the spent regeneration fumes are expanded through a gas turbine to provide the power required to drive the air compressor and very often to produce excess electrical power. In the TCC process, regeneration is effected at low pressure, hence the power requirements are small.

The nature of the reaction requires uniform contact between the oil vapors and the catalyst, as it is highly desirable to utilize each unit of catalyst to substantially the same extent. This has required much study, but has been successfully accomplished in separate ways because of other requirements of the two processes.

The first large scale unit, employing the Houdry fixed-bed process was placed in operation at Paulsboro, New Jersey, in 1936. This plant was manually operated and the minimum on-

Catalytic cases in a recent Houdry unit installation



stream time was about 30 min. It was found, however, that shorter on-stream times were desirable in order to increase the output of gasoline per unit of catalyst. To achieve this it was necessary to employ automatic valve control. With the shorter on-stream cycle, it was also necessary to increase the rate of combustion during regeneration, which led to the use of air under pressure. A combination of short cycle and pressure regeneration has been used in all subsequent Houdry fixed-bed cracking units and has resulted in a great increase in the rate of carbon removal and a proportionate increase in the production of gasoline from a given volume of catalyst.

In the use of the short cycle, the development of a suitable control or cycle timer was an engineering problem of considerable magnitude, but it was successfully solved. Not only does the cycle timer open and close valves and control other operations at the proper time, but it also serves as a safety feature to prevent accidental mixing of oil and air streams, which might occur through failure of some of the secondary equipment. In the case of mal-operation of a valve or the failure of certain equipment to function mechanically, the timer is automatically stopped and an alarm sounded. In this manner, it is always assured that the previous operation called for by the timer has been completed before a subsequent operation is begun.

In the first automatically controlled plant, one cycle timer was used to control the operation of a single catalyst case, necessitating the use of six timers in the plant. Although this original equipment is still in service, in one instance, two complete plants consisting of more than 12 catalytic cases are now being controlled by one timer.

The first three fixed-bed plants constructed employed water cooling in the cases for the removal of the heat liberated during regeneration. Later, because of certain mechanical difficulties with the water cooling system, and further, in order to improve temperature control, a cooling system employing molten salt was substituted for the water cooled system. It was fortunate that this improvement was made for without the use of a salt system the fixed-bed treating operation, so effectively conducted in connection with production of aviation gasoline distillates, could not have been nearly as successful as it has proved.

Numerous improvements have been made in the design of the air and oil distributing elements within the catalyst cases. Some of these have been in the nature of mechanical improvements, in order to enhance the distribution of the fluids and control of the temperatures; others have been materials in order to improve the serviceability of the equipment.

Purging the Catalyst

A very important process development has been the use of vacuum in addition to steam for the purging of oil and air vapors from the catalyst after the on-stream and regeneration phases of the cycle. Earlier, steam at moderate pressures had been used to effect the purging operation, but the improved method was adapted to effect better removal of oil from the catalyst and to avoid the adverse effect of steam thereon at high temperature and relatively high pressure. Further, changes were made in the method of repressuring the cases, in that use of steam was eliminated and the particular fluid involved was substituted.

From the process design standpoint, the importance of charging oil in vapor phase has been studied and here steam can be used as a vaporizing medium with negligible adverse effect upon the catalyst. Accordingly, when processing heavy oils, steam may be utilized not only as a control over the dewpoint of the case charge, but also to control the distribution and extent of the catalyst deposit, because its presence causes a lowering of the oil partial pressure. Part of the steam is introduced into the heater to decrease cooling and to lower the flash temperature in the tar separator, the overhead from which constitutes the case charge. The rest of the steam is added in the superheated state directly to the vapor stream leaving the tar separator. This serves to raise the temperature of the tar separator overhead above its dewpoint so as to evaporate entrained material and further to offset heat losses in the vapor line between the tar separator and the catalytic vessels. Through the skillful use of these features, it has been found possible to charge increasingly heavier stocks. Some plants have been operating with a case charge having an endpoint greater than 1000° F.

As the thermofor catalytic cracking process has been in commercial operation for only about 6 months, a great number of modifications based on commercial operations are not to be expected during this short time. The units now coming into production, however, reflect several modifications over the first units designed, mostly based on pilot plant operation. Probably the most important of these has been the solid bed type of reactor, which has resulted in simpification of design and offers an economical construction for the processing of corrosive stocks. As in the case of the fixed-bed Houdry units, an improvement in purging was rapidly developed, namely use of a solid bed of catalyst to insure thorough contact of the steam with the catalyst. Without doubt the next year will suggest other improvements for incorporation in existing or new units.

☆ ☆ ☆

Oil in Refinery Boiler Feed

by W. F. Schaphorst

ON A number of occasions the question has been asked whether there is a device on the market that indicates directly the quantity of oil in boiler feedwater.

So far as the writer knows, there is not. Without question such an "oil indicator" would be of value and the inventor would do well to let the world know about it. Unlike the maker of Emerson's famous mouse trap, the world will *not* build a path to the door of the inventor of an oil indicator unless he makes it known in some way or other that he has such a device to sell.

In view of the lack of a real "oil indicator," it seems that the most practicable way in which to determine the presence of oil with ordinary standard equipment is to install a good feedwater filter in the line.

Place a pressure gauge ahead of the filter and another gauge behind it so that the pressure drop through the filter can be observed at all times. When clean it will be found that the pressure drop is slight. As oil accumulates in the filter cloths the pressure drop increases. A curve can be plotted between time and dirtiness, based on the pressures, which will enable one to know with surprising exactness the amount of oil in the cloths at any time after installation.

If the filter is a good one, that is, if it extracts *all* the oil, as it should, the exact amount of oil can be determined by weighing the cloths while dirty and again when clean. The difference in weights, of course, is the weight of the oil.

☆ ☆ ☆

Creole Petroleum to Double Venezuelan Refining Capacity

☆ Committee weighs plan to enlarge existing plants or build new refinery

ACCORDING to an high official of the Creole Petroleum Corporation, an affiliate of the Standard Oil Company (N. J.), that corporation will either enlarge its existing refineries in Venezuela to the extent of doubling the present capacity, or will erect an additional new refinery.

The move is in fulfillment of an agreement between Creole and the Venezuelan government made about a year ago. The project is scheduled for completion as soon as conditions permit, but not later than 5 years after cessation of the war against the Axis powers.

Preliminary steps, which will lead to Creole's decision regarding whether to enlarge present refineries or to build the new refinery are now nearing completion. Since early February, a committee of Creole's technical experts has been in Venezuela weighing the various factors. By the time this is published, the committee will have returned to the United States to submit its recommendations.

Creole now has two refineries operating in Venezuela with a combined capacity of about 40,000 bbl. per day. The first, a crude topping unit operating on light Lake crude, is located at La Salina on the eastern shore of Lake Maracaibo. The second, a vis-breaker operating on Quiriquire and Jusepin crudes, is located on the river San Juan near Caripito in eastern Venezuela. Regardless of whether these refineries are enlarged, or a new refinery built, the move will result in approximately doubling Creole's present Venezuelan refining capacity; in either case, a full range of products, including aviation gasoline, will be manufactured.

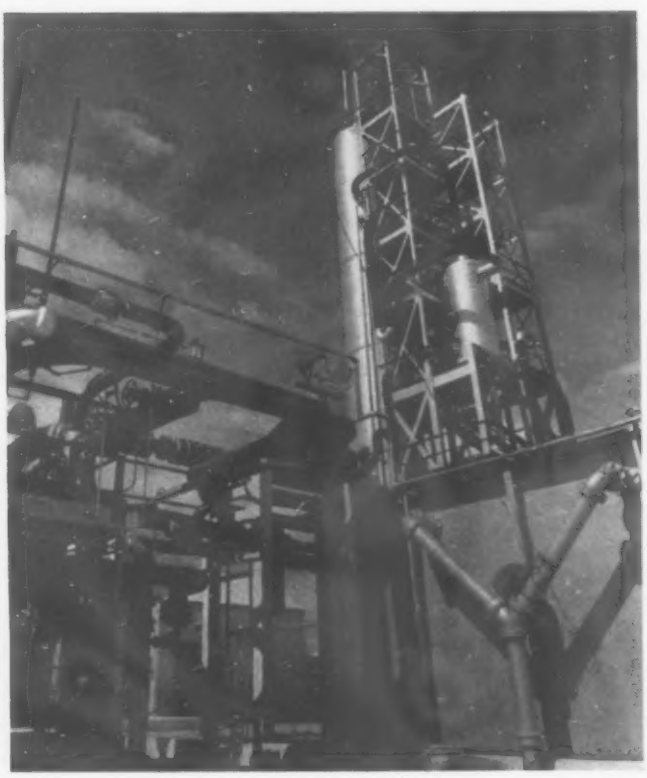
The committee studying the project consists of John Kalb, representing production; Brian Mead, representing refining; E. L. Kares, representing engineering; M. G. Gamble, representing marine, and J. E. Lindroth, economic adviser.

Before departing for Venezuela in February, this committee conducted an exhaustive survey and study of the matter in this country. This included the types of refinery equipment for processing Venezuelan crudes of qualities now known to be available, the extent of the alterations required to expand and revise present refineries, the technical and engineering problems involved, the availability of sites for a new refinery with regard to crude supply, transport, marine and shipping facilities, etc. These studies were continued in Venezuela and the committee, on its return, will present its recommendations.

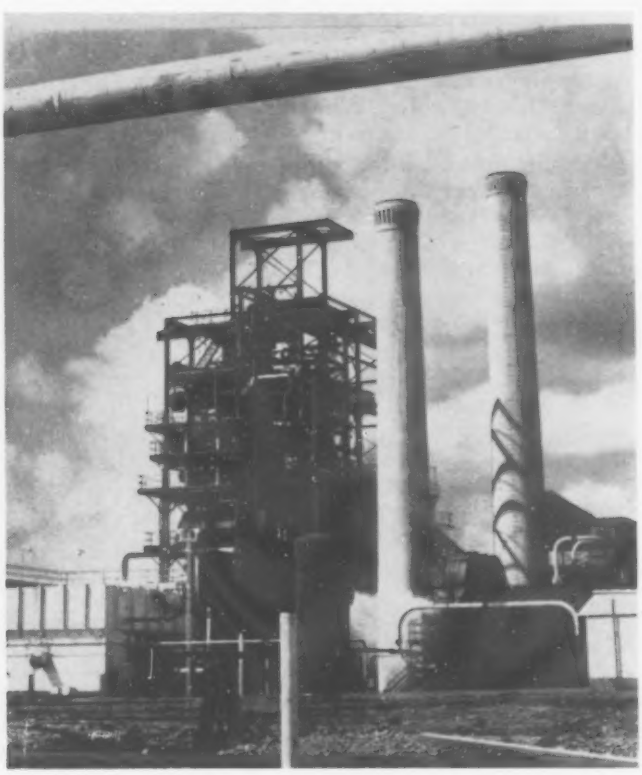
Prior to August 19, 1943, the affiliates of Standard Oil Company (N. J.), operating in Venezuela, included the Lago Petroleum Company and the Standard Oil Company of Venezuela. By dissolution and merger, Creole Petroleum Corporation, on that date, became the successor and operator of the properties. Officers of the company are C. H. Lieb, president; J. L. Cluley, vice president and treasurer; L. F. McCollum, A. T. Proudfit, and J. A. Clark, vice presidents, and M. H. Eames, secretary.

☆ ☆ ☆

Refinery at La Salina



Creole's visbreaker at Caripito



● Completely equipped Pilot Plants and a modern Laboratory are in 24-hour operation at Foster Wheeler's Carteret works. Its facilities are utilized to determine the basic designs for commercial processes, including fluid catalytic cracking, polymerization, precise fractionation and others. Data on chemical reactions to 1500°F. and 3000 lb. pressure per square inch are obtained.

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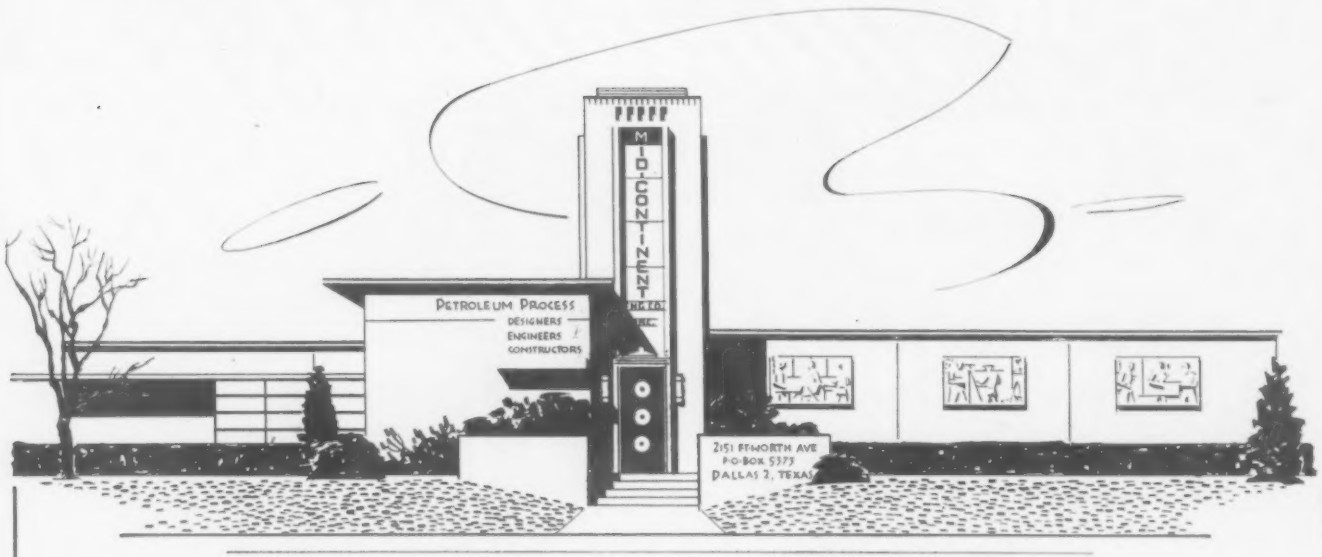

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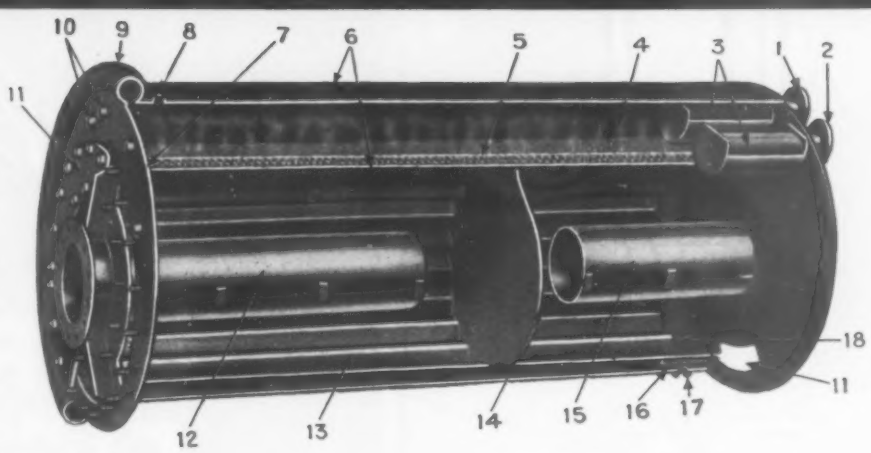

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17—Feed Water Connection
18—Exhaust Gas Outlet from side conduits formed by extended heating surfaces

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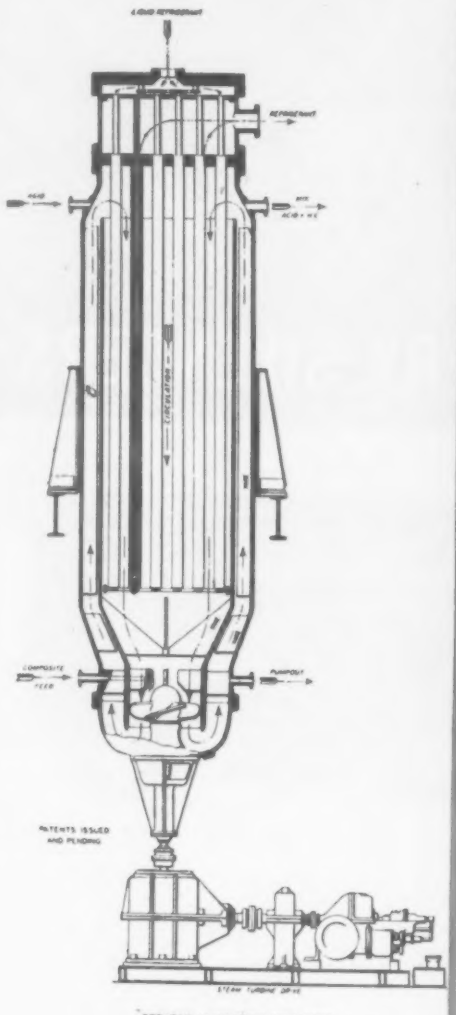

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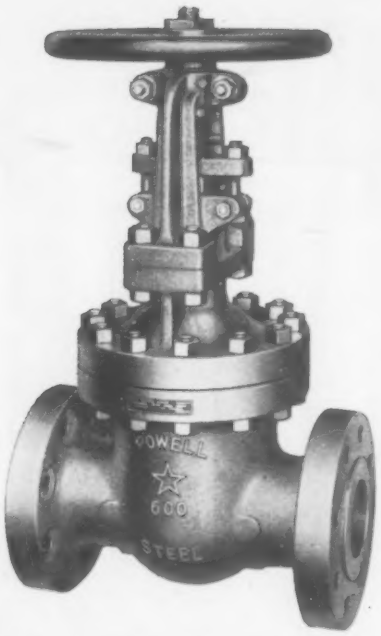

Fig. 6003—Class 600-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged bonnet, and taper wedge solid disc.

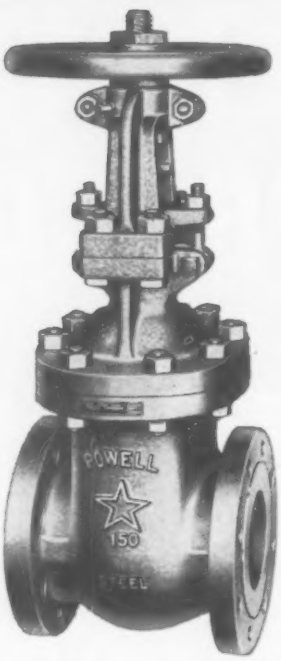

Fig. 1503—Class 150-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged bonnet, and taper wedge solid disc.

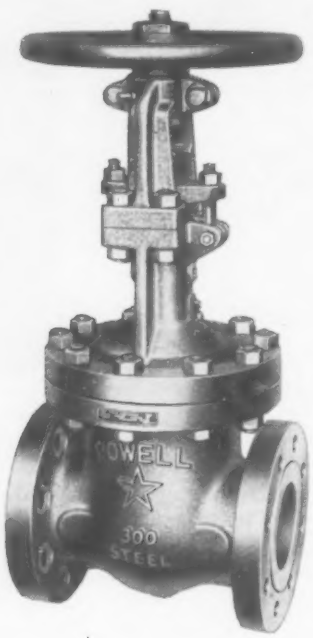

Fig. 3003—Class 300-pound Cast Steel Gate Valve. Has flanged ends, outside screw rising stem, bolted flanged bonnet, and taper wedge solid disc.

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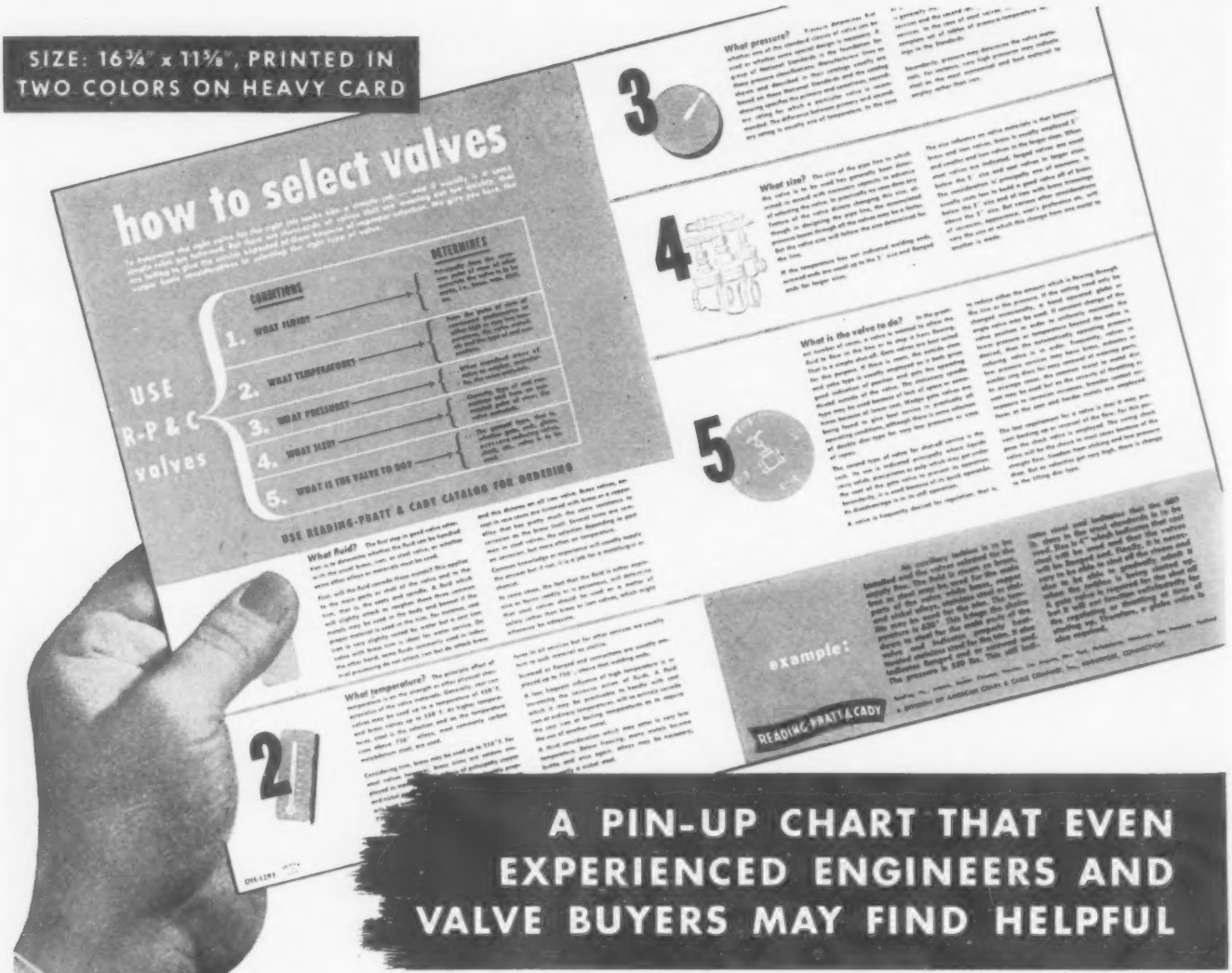

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1. **The fluid, from a corrosive standpoint, determines whether the valve should be made of brass, iron, steel, etc.**
2. **Temperatures, from the point of view of continued performance, determine valve materials and end connections.**
3. **Pressure determines the standard class to employ; and, secondarily, valve materials.**
4. **Size determines valve capacity, end connections and valve materials.**
5. **What the valve is to do determines whether to use cock, gate, globe, check, pressure-reducing valve, etc.**

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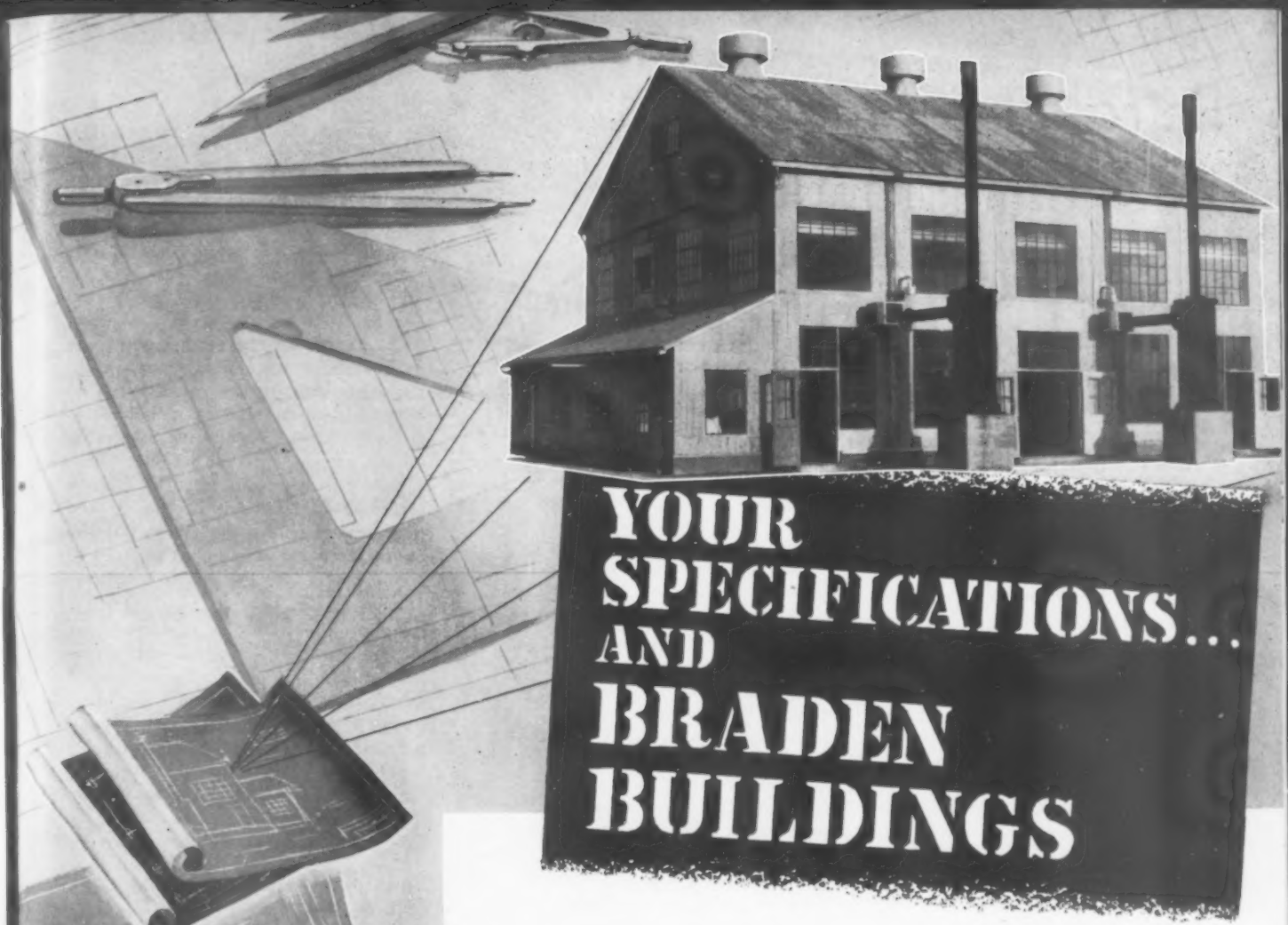

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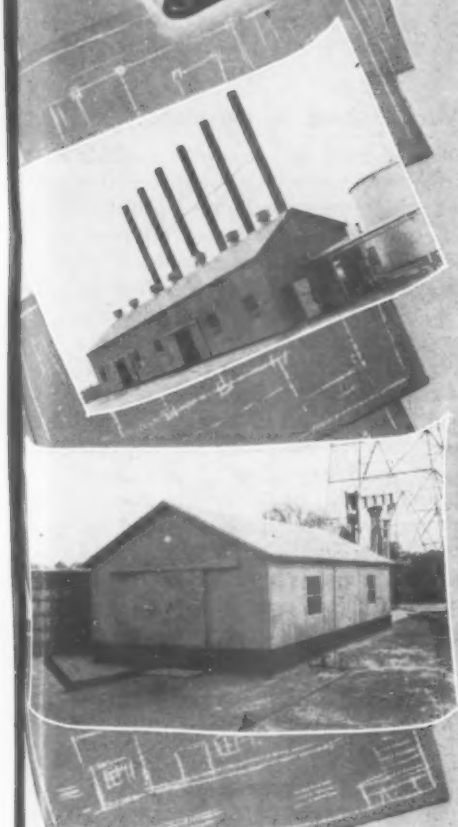

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Petroleum Refining As A Chemical Industry

☆ Remarkable future advancements in the production of petroleum chemicals predicted

PETROLEUM ENGINEER Exclusive Feature

by Gustav Egloff

Director of Research, Universal Oil Products Company

THE petroleum industry is increasingly becoming known as a chemical industry. Its current and projected processes are aimed at the production of pure compounds having precise characteristics, particularly in respect to octane ratings. As the industry continues to develop, it will become more and more a starting point for a vastly greater number of useful chemical derivatives than are produced from coal, which has been for many decades a primary source of hydrocarbon derivatives, such as dyes, drugs, explosives, perfumes, and flavors. With the products from coal carbonization as raw materials, 500,000 chemical compounds have been made. As the predominating substances in coal and coal tars are aromatic, the possible derivatives are limited to those of an aromatic character. The newer developments in petroleum chemistry have opened a field of much broader scope, particularly in the field of derivatives of aliphatic hydrocarbons. In this latter group the reaction possibilities are almost unlimited. The number of starting materials of paraffin structure increases from one compound having one carbon atom to the molecule to 35 isomeric compounds having 9 carbon atoms per molecule. The number of olefin hydrocarbons containing 9 carbon atoms in 153, which further extends the field of possible chemical derivatives. The chemical industry built upon petroleum as a raw material is a minor one compared to that which will eventually develop. At the present time it represents less than 1 per cent by weight of the crude oil refined last year.

The effect of the present war on petroleum refining has been markedly to accelerate chemical process developments, some of which were already being used before the war began. In the years preceding Pearl Harbor refining processes were aimed primarily at increasing both the quantity and the quality of motor fuels and lubricants from each barrel of oil processed. In this period the octane ratings of motor and aviation fuels were increased by utilizing the better hydrocarbons made available by the application of chemistry and chemical engineering.

In the last two years of war, processes have been catapulted out of the laboratory into commercial scale operation, which would have required ten or more years for their development under peacetime conditions. The speed was caused by the great demands for aviation gasoline to fuel military planes, for synthetic rubber to take the place of supplies cut off by the Japanese invasion of Malaya, and for high explosives such as TNT and ammonium nitrate.

In 1930 the octane number of regular grade gasoline averaged about 60 and premium grade 70. At the time of our entry into the war in 1941, the octane number of regular grade gasoline had increased to about 75, whereas premium grades averaged about 80. In 1930 fifty-six per cent of United States Army Air Corps aviation fuel requirements were met by gasolines having anti-knock ratings from 58 to 65. The remaining 35 to 42 per cent was met by fuels having octane numbers of about 87. The octane rating requirements for aviation gasolines have risen steadily. In 1934 the United States Army Air Corps carried out the first full scale airplane experiments on 100-octane number fuel and in 1937 army fuel for pursuit aircraft was standardized at this quality. At the present time United States Army aviators are using super fuels having performance characteristics exceeding those of 100-octane number.

During the period from 1930 to 1942 the use of commercial airplanes for both passenger and express transportation increased many fold. In 1930 commercial airlines carried about 375,000 passengers, whereas in 1942, 3,690,000 passengers were transported. The cargo planes in 1930 transported 360,000 lb. of goods and 39,000,000 lb. in the year 1942. It is predicted that in the postwar period air transportation will be enormously increased.

Hydrocarbon Separation

The physical difficulties of separating individual hydrocarbons from petroleum and natural gas by early available fractionation processes acted for a long time as a brake on their commercial recovery and hence on the manufacture of chemical derivatives from them. Most of the work on the recovery of pure hydrocarbons from petroleum was in the separation of the constituents of natural gases, or refinery still gases, as these contain principally methane, ethane, propane, and the butanes, which can be separated in specially designed fractionating equipment. One of the early results of this separation was the use of regulated amounts of butanes to give proper vapor pressure to gasolines.

The introduction of super fractionating equipment for the separation of individual hydrocarbons from petroleum and its products greatly encouraged attempts to produce individual hydrocarbons. Where the industry was content for a long time to obtain distillate fractions of relatively wide boiling ranges, super-fractionators have now permitted the separation of hydrocarbon fractions boiling within narrow ranges. Without the utilization of these newer types of fractionators, progress in the recovery of individual hydrocarbons and the manufacture of hydrocarbon derivatives would have been greatly retarded.

Hydrocarbons in Gasoline

The chemists and engineers working in the petroleum refining industry have brought all their combined capabilities and acumen to bear on improving processes and manufacturing products of definite chemical composition. Prior to 1930, little was known of the individual hydrocarbons and their percentages present in liquid portions of crude oil, and there is much still unknown regarding the individual components. The first project for the separation and identification of hydrocarbons in petroleum was established in 1927 by The American Petroleum Institute, financed by John D. Rockefeller and Universal Oil Products Company. In 16 years of work in the Bureau of Standards Laboratory, Dr. Rossini and associates have isolated 52 individual hydrocarbons from the fractions of seven representative naphthas boiling up to 176°C. Three of the naphthas were from Texas fields and one each from fields in Oklahoma, Pennsylvania, Michigan, and California.

From these naphthas six normal paraffins, 19 *iso*paraffins, 16 cycloparaffins, and 11 aromatic hydrocarbons have thus far been separated. The work re-

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ported was most complete in the separation of paraffins and cycloparaffins boiling from 40 to 102°C., and for aromatics boiling up to 160°C. It is concluded that the gasoline fractions of crude oils are characterized by the relative amounts of normal paraffins, *iso*paraffins, alkylcyclopentanes, alkyl cyclohexanes, and aromatics that they contain. It is interesting to note that none of the naphthas contain detectable amounts of 2, 2, 3-trimethylbutane, or 2, 2, 4-trimethylpentane.

In the fractions of a Mid-Continent petroleum boiling higher than gasoline, 11 more individual hydrocarbons have been isolated and identified. Six of these are aromatic in character, three are partially hydrogenated alkyl naphthalenes, one is a phenylcyclopentane, and one is a paraffin, normal dodecane. The hydrocarbons in lubricating oils are principally polynuclear hydrocarbons made up of six membered rings, either partially or completely hydrogenated, with alkyl substituent groups. Both normal and *iso*paraffin hydrocarbons are present, but individual compounds in these groups have not been isolated.

Rapid and effective methods of separating gasoline hydrocarbons have been developed at the Bureau of Standards so that estimates of the kind and quantity of hydrocarbons in petroleum fractions can be made more rapidly. The methods involve the use of silica gel for selectively adsorbing aromatic hydrocarbons and sulphur compounds and subsequently removing the sulphur compounds from the aromatic fraction by another adsorbent step. The desulphurized aromatic fraction and the non-absorbed fraction comprising naphthenes and paraffins are separated into small fractions by distillation. The eight possible aromatic compounds boiling below 160°C. are readily obtained and the individual paraffin and naphthene hydrocarbons are also obtainable by efficient fractionation methods. Knowing the exact nature and amount of the compounds present in gasolines enables closer application of scientific principles in refining processes and we can, therefore, expect much greater developments in the near future. The oil industry now has a consciousness in respect to chemical compounds from petroleum that was absent in eras preceding the injection of science into its industrial projects.

Thermal Cracking

The cracking process, which has been such a great factor in the conservation of petroleum resources, has contributed largely to the transformation of petroleum refining into a chemical industry. The olefin and aromatic hydrocarbons formed in cracking are more reactive than the paraffin and naphthene hydrocarbons present in straight-run petroleum fractions, and as a result, the production of hydrocarbon derivatives from petroleum has been greatly stimulated. Besides more than doubling the amount of gasoline obtainable from crude petroleum, the thermal cracking process has supplied enormous quantities of hydrocarbon gases containing larger amounts of olefins, and these have been converted into high octane rating polymer gasolines and chemical derivatives.

Catalytic Cracking

The wide application of catalysts in the cracking of petroleum is an outstanding contribution to the war effort in producing aviation gasoline. This process is a basic improvement over thermal cracking, which makes possible not only the production of motor fuels of higher antiknock rating but of aromatic hydrocarbons as well, including benzene, toluene, and the xylenes. The hydrocarbon gases from these operations contain increased amounts of butylenes and butanes as compared with those produced in thermal cracking reactions. Catalytic cracking not only produces gasolines of higher octane rating than thermal cracking, but also produces increased yields, which places it in the first ranks of crude oil conserving processes developed by the industry.

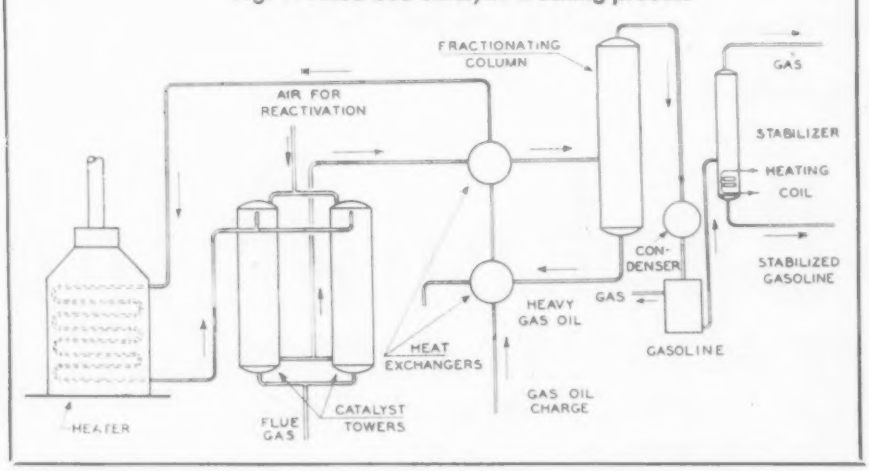
A. Fixed bed catalytic process. The first catalytic cracking processes were known as fixed bed processes. Granules or pellets of natural silicate minerals or synthetic silica-alumina composites were employed in stationary beds through which preheated oil vapors were passed to effect their conversion. After a period of service during which carbonaceous materials were deposited on the catalyst granules, the stream of oil vapors was diverted to contact with fresh catalyst and the carbonaceous deposits were burned off with air or flue gases containing oxygen.

Fig. 1 shows the flow in the fixed bed catalytic cracking process. The gas oil charge passes first in heat exchange relationship with heavy gas oil from the fractionating column of the plant, and then in heat exchange with cracked products from the catalyst towers. The partially heated charge then passes through a heater in which it is vaporized, and the vapors pass through a catalyst bed while the other bed is reactivated. The products of cracking are fractionated in standard equipment to produce gases, stabilized gasoline, and heavy gas oil, which may be recycled with the charge or thermally cracked in an auxiliary plant.

B. Fluid catalytic process. The catalytic cracking process known as the fluid flow type involves the use of catalyst in finely powdered condition maintained in turbulent flow by the stream of oil vapors in a cracking zone. The spent catalyst is subsequently separated, and reactivated with air by burning off the carbonaceous deposit. The regenerated catalyst is then contacted with fresh oil vapors from the heating tubes. Fig. 2 shows a flow in a plant of this type.

The raw oil charging stock, usually as oil, is preheated by heat exchange with a recirculating stream on the first-stage fractionating column. It then goes to the catalyst-to-oil heat exchanger, where it receives further preheating from a stream of catalyst that circulates between the exchanger and the regenerator. Any additional heat required by the reactor is supplied by means of a fired tubular heater. The raw oil then enters the reactor riser, where it comes into contact with the hot regenerated catalyst flowing from the regenerator. The oil is now completely vaporized, and the catalyst is fluidized to a relatively light condition so that the mixture flows upward into the reactor. Usually recirculated process gas or steam is in-

Fig. 1. Fixed bed catalytic cracking process



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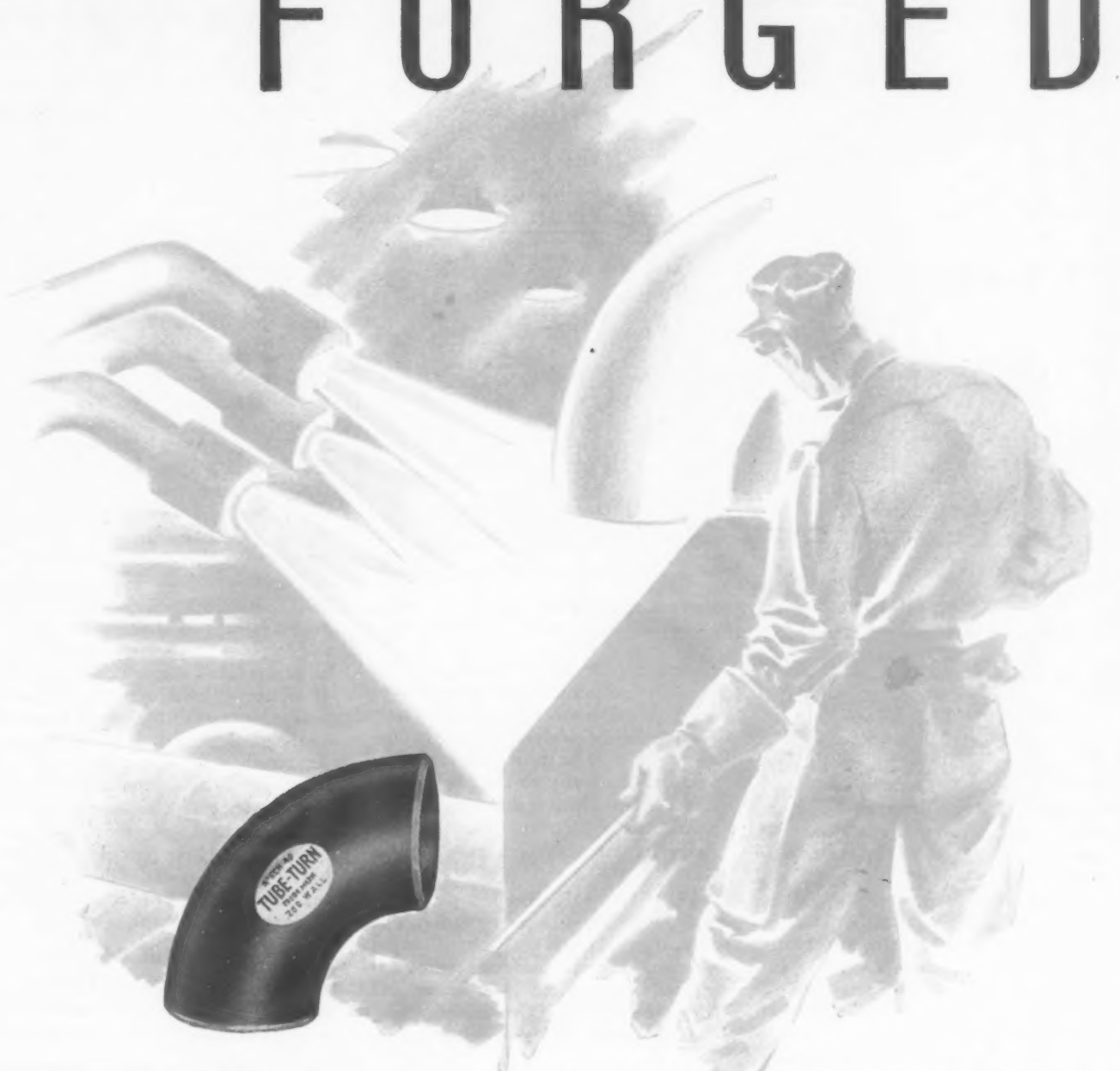

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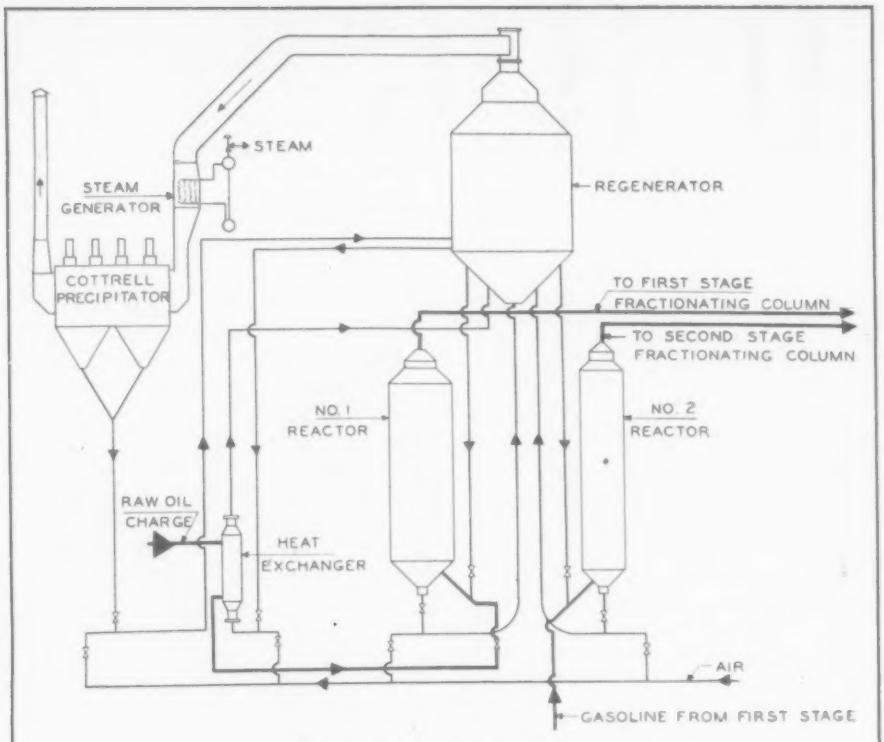


Fig. 2. Fluid catalyst cracking plant

jected into the reactor riser to aid in fluidizing the mixture.

The vapors leaving the reactor carry some of the catalyst fines with them. The major portion of these catalyst fines is recovered by passing the vapors through cyclone separators. The remainder of the fines is recovered as a slurry at the bottom of the fractionating column.

The products of the reaction are then fractionated in the first-stage fractionating column and gas-concentrating equipment, from which a gasoline cut is returned to the second-stage reactor for treating—usually at a somewhat lower space velocity and temperature. Heat is supplied to the second-stage reactor principally by hot catalyst from the regenerator, the catalyst-to-oil ratio in this stage being relatively high. From the second-stage reactor the treated product passes to the second-stage fractionating and gas-concentrating sections for separation.

The air required for combustion of the carbonaceous material on the spent catalyst enters at the base of the regenerator risers and carries the catalyst upward into the regenerator. The regenerated catalyst flows into the draw-off well, down to the two reactors, and on to the catalyst-to-oil heat exchanger.

The fluid flow process may be operated single stage, the gasoline produced being given its finishing treatment by chemical or physical methods other than recontacting with the cracking catalyst.

C. Moving bed catalytic process. In another type of operation known as the moving bed process, catalyst pellets or beads move downward through a reactor and oil vapors either pass countercurrent to the catalyst flow or concurrent with it. The spent catalyst is elevated mechanically to the top of a regenerator, in which it moves downward against a rising stream of air that restores its activity for further use in cracking.

Fig. 3 shows the flow in a plant embodying the moving bed operation. The oil charge, which is an intermediate gas oil fraction from a crude oil topping operation, is vaporized in a heater and enters the bottom of the reactor to flow countercurrent to the moving bed of catalyst particles. Any catalyst dust formed by abrasion is separated, and the cracked vapors are subjected to the customary fractionation step to recover gases, gasoline, and gas oil fractions. The spent catalyst from the bottom of the reactor is mechanically elevated and introduced to the top of the regenerator wherein it flows downward against a rising stream of air to burn off carbonaceous deposits. From the bottom of the regenerator the catalyst passes to another elevator, which raises it to a sufficient height to permit its flow to the reactor.

Gasoline Inhibitors

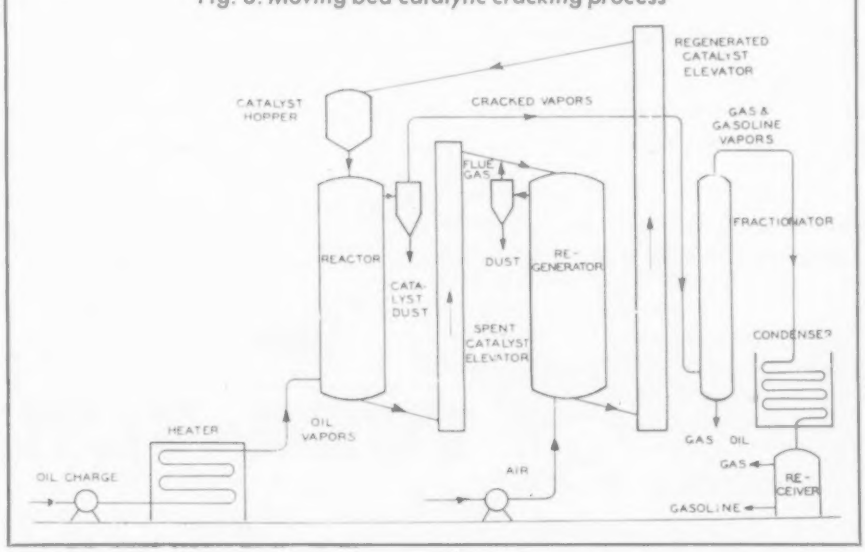
To avoid losses in refining cracked gasolines containing olefinic hydrocarbons that tend to form gummy deposits on storage, due to oxidation, very small amounts of chemicals are added to arrest their gum-forming tendencies. These compounds are designated as inhibitors; they have an anti-oxidant action and prevent the formation of peroxides, which accelerate gum formation.

The types of compounds that have been found effective as inhibitors comprise certain phenols, amino phenols, and amines. It is frequently possible to stabilize a cracked gasoline by the addition of an active inhibitor in a concentration as low as 0.001 per cent by weight of the gasoline, and the use of amounts greater than 0.006 per cent is seldom necessary. Such concentrations correspond to about 1 molecule of inhibitor to 40,000 molecules of gasoline hydrocarbons. About 85 per cent of all marketed gasolines now contain inhibitors, and the cause of petroleum conservation has been thereby greatly advanced.

Polymerization of Olefins

One of the outstanding and the earliest contributions to making the oil industry a chemical one was the discovery

Fig. 3. Moving bed catalytic cracking process



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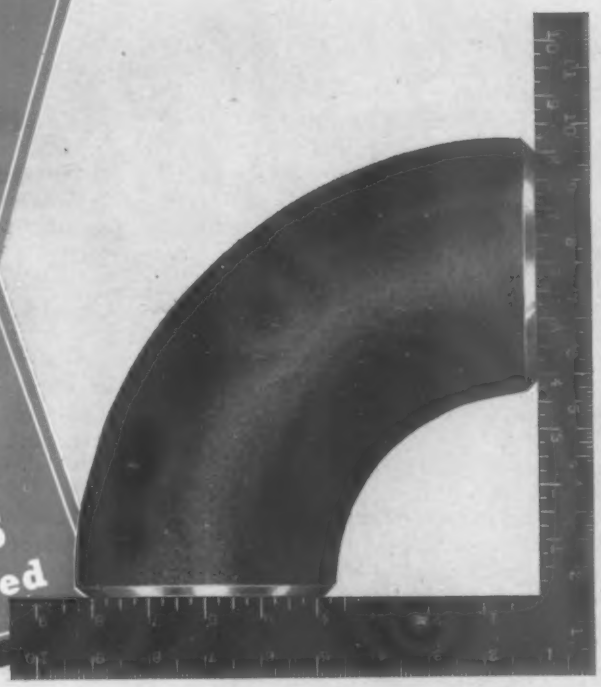

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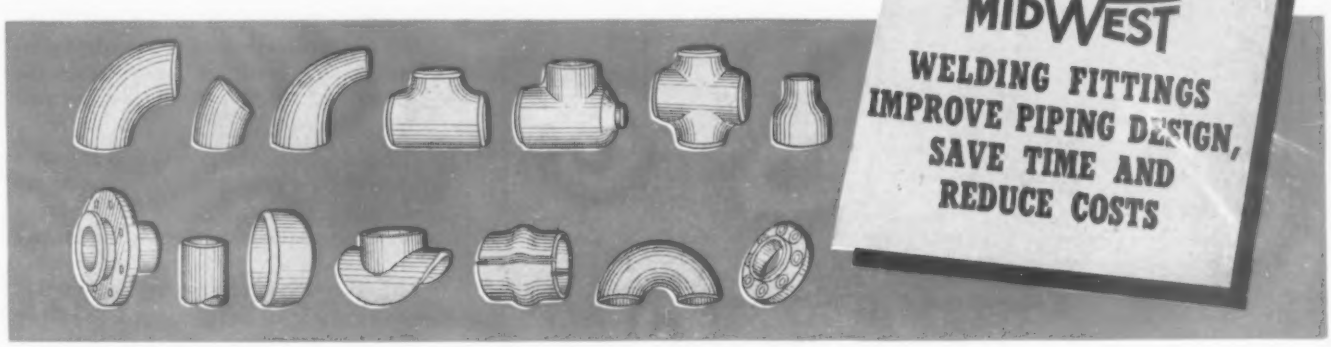


MIDWEST WELDING FITTINGS IMPROVE PIPING DESIGN, SAVE TIME AND REDUCE COSTS

of the process using the solid phosphoric acid catalyst. Propylene and butylenes present in cracked gases were converted into gasoline of over 80-octane number, a much higher rating than that of the gasoline produced as the direct result of thermal cracking. This process has conserved and is conserving many millions of barrels of crude oil by more profitably utilizing cracked gases, which prior to its discovery were burned under stills and boilers. A number of the solid phosphoric acid catalyst units operating in refineries, are producing codimer gasoline, which upon hydrogenation yields an aviation gasoline component.

Sulphuric acid is also used as a catalyst in polymerizing olefins to produce polymer gasoline.

A. Solid phosphoric acid catalyst. The solid phosphoric acid catalytic process for polymerization of olefins in cracked gases is an integral part of a large number of cracking plants. By suitably correlating temperatures, pressures, and rates of flow, the character of the liquid polymers can be varied. Operation on stabilizer overhead fractions, i.e., principally propane, propylene, butanes, and butylenes, produces polymer gasolines of 80 to 82-octane rating. Polymerization of the butylene fraction yields *iso*octene mixtures, which are hydrogenated to *iso*octanes of 95-octane rating.

Fig 4 shows the flow in a catalytic polymerization unit employing solid phosphoric acid catalyst. The catalyst towers are arranged so that they can be operated either in parallel or in series. Stabilized polymers are used in the absorber to retain any unpolymerized olefins and return them to the polymerizing step.

B. Hydrocodimer. An increasing use is being made of the solid phosphoric acid polymerization process for the production of polymers, which when hydrogenated give high octane ratings, the hydrogenated material being known as hydrocodimer. In this process gases containing butylenes as their major olefinic constituents are employed, and operating conditions are adjusted to yield products having the desired octane rating.

C. *Iso*octanes. By subjecting butane-butylene mixtures to contact with solid phosphoric acid or sulphuric acid polymerizing catalysts, *iso*octenes are produced, which are hydrogenated to *iso*-octanes, including 2, 2, 4-trimethylpentanes (the standard *iso*octane having 100-octane rating) and also the 2, 2, 3- and the 2, 3, 4- compounds. These *iso*-octanes are contributing to the superior quality of our present aviation fuels. In the postwar period they will be used in aviation gasoline and may be used in motor fuels for civilian cars when engines are designed that can use them efficiently.

Fig. 4. U.O.P. catalytic polymerization unit

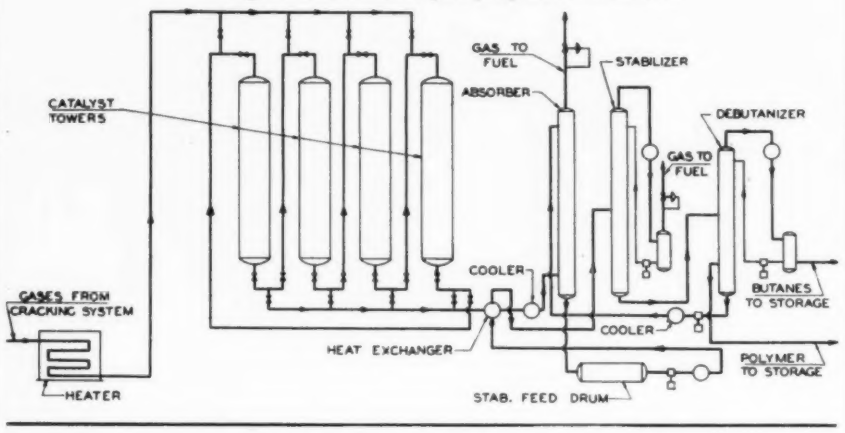
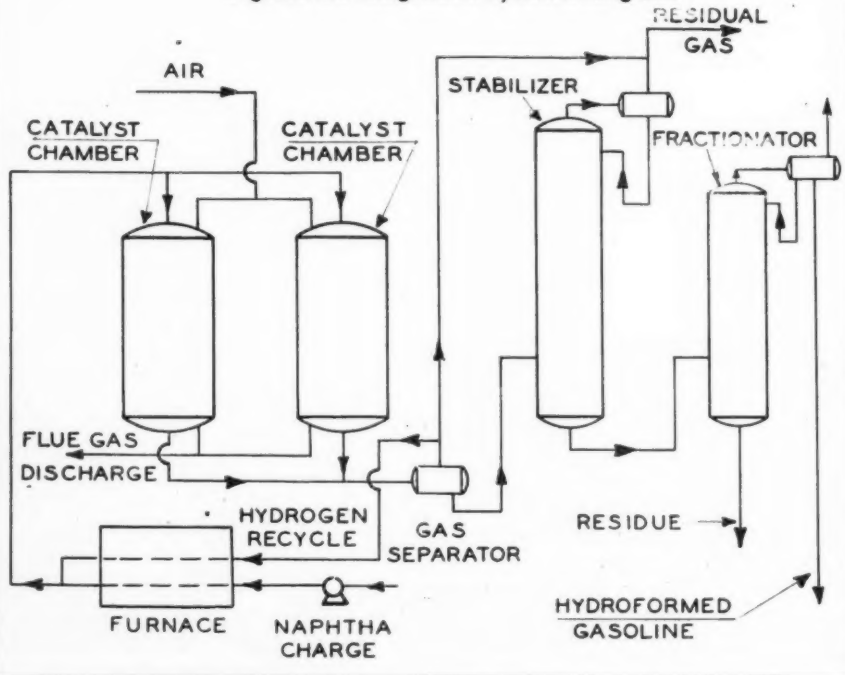


Fig. 5. Flow diagram of hydroforming unit



Dehydrogenation of Butanes

To produce increased amounts of gaseous olefins for polymerization and for use in alkylation reactions, a catalytic dehydrogenation process has been developed that operates on butanes separated by fractionation from refinery or natural gases. When normal butane is charged, butylenes are obtained that can be further dehydrogenated in a second processing step to form butadiene for the synthetic rubber industry, or the butylenes can be used to alkylate *iso*-butane.

This same catalytic process may also be applied to the dehydrogenation of propane or mixtures of propane and butanes to produce olefins for polymerization.

Hydroforming of Naphthas

The process of hydroforming (catalytic reforming of gasolines or naphthas in the presence of hydrogen) was originally developed to produce high octane rating fuels from naphthas of low octane number. However, it now operates on selected charging stocks for the production of toluene and produces motor fuel stock and aviation stock as by-products. Hydroformed products are highly aromatic and toluene is recovered from fractions of proper boiling range by solvent extraction. This method of producing toluene is a chemical conversion process. The hydroforming process produces many times the amount of toluene obtained from coal tars.

In hydroforming, regulated amounts of hydrogen are mixed with the naphtha charge before contact is made with the catalysts and by suitably interrelating temperature, pressure, time of catalytic contact, and the ratio of hydrogen to naphtha, dehydrogenation rather than hydrogenation occurs so that aro-

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matics are formed and the production of olefins and carbon is suppressed. Fig. 5 shows the flow in a plant designed for hydroforming naphtha.

Alkylation of Isobutane

Processes for alkylating *iso*butane with olefins to produce liquid *iso*paraffins have been developed to supplement processes involving first polymerization of gaseous olefins to liquid olefins and then hydrogenating the liquid products. The production of liquid *iso*paraffin hydrocarbons by alkylation is a one step process as contrasted with the two step process involving first polymerization and then hydrogenation.

A. Thermal process. *Iso*butane is alkylated with ethylene at temperatures of the order of 550°C. and pressures of the order of 5000 lb. per sq. in. In this process neohexane (2, 2, dimethylbutane) is formed. Neohexane has an octane rating of 94, is very susceptible to tetraethyl lead, and possesses a volatility that makes it a highly suitable component in aviation gasolines.

B. Sulphuric acid process. The alkylation of *iso*butane with butylenes is catalyzed by sulphuric acid of about 90 to 100 per cent concentration. Low temperatures of about 0 to 10°C. are used to reduce the oxidizing tendencies of the acid. The alkylates produced have octane ratings of the order of 93 and are used in aviation fuel blends.

The general flow in a plant for alkylating *iso*butane with butylenes in the presence of sulphuric acid is shown in Fig. 6. The charge consists of a proportioned mixture of *iso*butane and butylenes in which the *iso*butane is in molal excess. A certain amount of the catalyst is consumed during the reaction and makeup acid is added to offset the loss. The mixture of acid and reactants is circulated through a cooler to maintain the temperature necessary to minimize the oxidizing effects of the acid.

C. Hydrogen fluoride process. Hydrogen fluoride is a catalyst that is used commercially in the alkylation of *iso*butane with olefins. Ordinary temperatures can be employed and alkylate products having octane numbers of the order of 93 are produced. Addition compounds of hydrogen fluoride and hydrocarbons are easily decomposed to liberate hydrogen fluoride for reuse in the process.

Fig. 7 shows the flow of the process when liquid hydrogen fluoride is used as a catalyst in alkylating *iso*butane with butylenes. The charge is a mixture of *iso*butane and butylenes with the former in moderate excess. The major portion of hydrogen fluoride is recycled from the settler and further portions are recovered from the alkylate product by stripping and by moderate heating of residual products. A treater containing a granular solid is interposed between the de*iso*butanizer and the fractionator for recovering normal butane, so that the last traces of fluorine are removed.

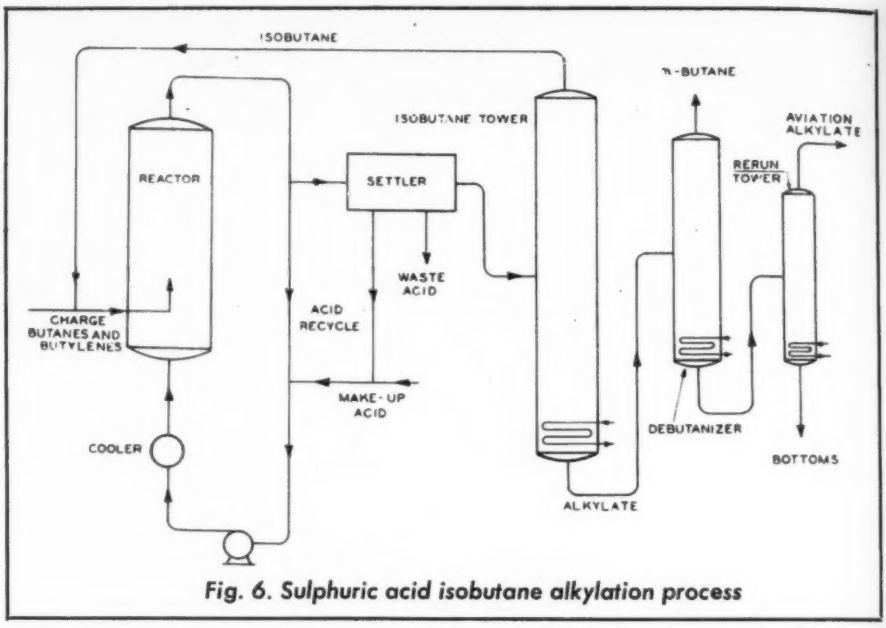


Fig. 6. Sulphuric acid isobutane alkylation process

Alkylation of Benzene

Benzene may be alkylated either with ethylene or propylene to produce respectively ethylbenzene and *iso*propylbenzene (cumene) in the presence of solid phosphoric acid catalysts. The benzene and the olefin are pumped through stationary beds of the catalyst and the products are fractionated to recover the alkylated derivatives and unreacted benzene and olefin for recycling.

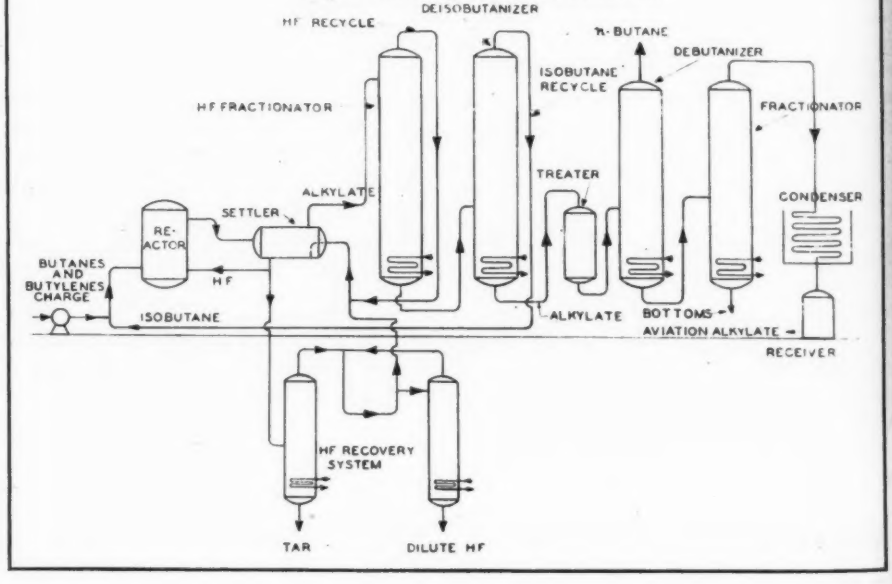
Isomerization of Paraffins

A. Normal butane. *Iso*butane being the key hydrocarbon in paraffin alkylation processes, a shortage developed, and processes for the catalytic isomerization of normal butane to *iso*butane were developed for increasing the available supply. In these isomerization processes some of the first catalysts used were composites of aluminum chloride and alumina, but newer developments utilize a flow in which aluminum chloride is dissolved in liquid normal butane charged to the process and reaction is brought about as the solution passes through a bed of granular carrier and the aluminum chloride is continuously deposited thereon. Fig. 8 shows the flow in the latter type of process.

B. Normal pentane and normal hexane. Normal pentane and normal

(Continued on Page 110)

Fig. 7. HF alkylation of isobutane



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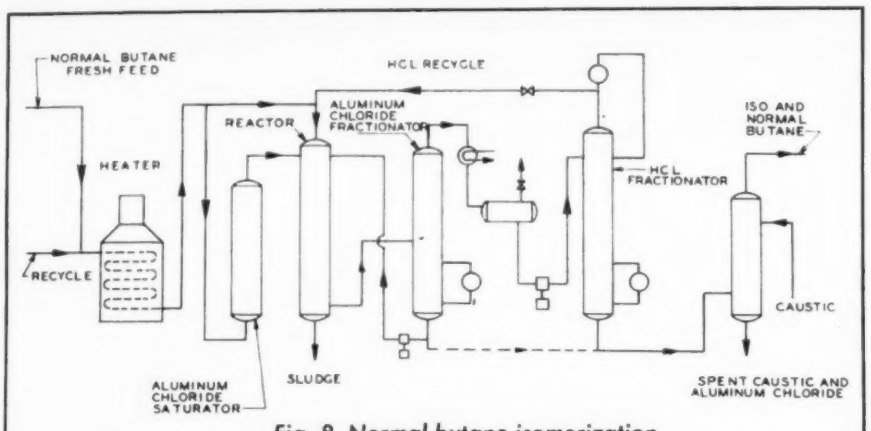


Fig. 8. Normal butane isomerization

(*Continued from Page 106*)

hexane fractions of paraffinic gasolines are now being isomerized with aluminum chloride catalysts, using operations similar to those employed in the isomerization of normal butane. With proper modifications of temperatures, pressures, and flows, *iso*pentane and *iso*hexanes have been produced in satisfactory yields. As more is learned about the mechanics of these reactions and the technique necessary for conducting them on a large scale, they will find further application in producing hydrocarbons of more highly branched structure from naphtha fractions having inferior antiknock ratings.

Triptane

Triptane is the most powerful hydrocarbon known for use in internal combustion engines. Its antiknock properties are of such magnitude that no commercial engine has been built capable of utilizing the full power value of pure triptane. When used as a component of aviation gasoline, it would enhance the performance of present day aircraft engines and make possible the design of future engines of even greater power and efficiency.

Although its existence has been known for years and some of its physical properties have been determined, triptane has been a laboratory curiosity because the known methods of producing it involve the classical but impractical Grignard reaction. Reported costs for producing triptane in very small amounts in the laboratory by these methods have run to such fantastic figures as $3000 per gal. It has been reported that a batch of triptane was produced for experimental purposes at a cost of $40 per gal. A new triptane process has been developed that could produce triptane for less than $1 a gal.

Regarding the effect of motor fuel improvement on aerial warfare, it is fitting to quote the following passage from "Victory Through Air Power" by Major Alexander P. deSeversky:

> "What if a new fuel, so light and compact that it solves the problem of range, were suddenly developed? . . . What if the efficiency of engines were raised to cut down gas consumption to a fraction of the present consumption? It was not so long ago that I flew with engines consuming 0.7 pound of gasoline per hour per horsepower at cruising speeds. Recently, in long-range pursuit flights, my engine consumed only 0.35 pound—a decrease of 100 per cent which means double the range, double the striking power, or a combination of both. Another such doubling of engine efficiency would, at one sweep, give the present Condor type of Nazi bomber, with a range of five to seven thousand miles, more than enough to lay the entire United States wide open to bombing, even with the existing Axis aviation equipment. The same kind of transformation would be achieved if the specific weight of fuels were cut in half."

Diesel Fuels

The combustion characteristics required in diesel fuels are opposite in character to those inherent in a good gasoline. The diesel fuel must ignite by the heat of compression, and the best fuels of this character are of the knocking variety. This tendency is measured by comparing the performance of a test fuel with mixtures of cetane and alpha methylnaphthalene, the centane being the knocking hydrocarbon and the naphthalene being the non-knocking component. Corresponding to the use of octane numbers in rating gasoline, cetane numbers rate diesel fuels, and for satisfactory operation, values of over 40 cetane numbers are considered desirable. As many light diesel fuels, which consist of straight run gas oils and intermediate boiling range cracked fractions, have low cetane numbers, recourse is had to the use of special additives that alter combusion characteristics in the direction of increased knocking and corresponding ease of ignition. Some of the better known diesel fuel additives are ethyl nitrate, amyl nitrates, and acetone peroxide. These compounds may be used in amounts from 0.5 per cent and higher, one limitation being that they may unduly depress the flash-point of the fuel. Excessive amounts lower the engine economy and instigate corrosion troubles.

Lubricating Oils

In the last decade or so the petroleum refiner has made remarkable advances in the technique of lubricating oil manufacture. Not only have lubricating hydrocarbons been synthesized, but the properties of both natural lubricants from petroleum and the synthetics have been improved by the addition of small amounts of modifiers, which include pourpoint depressors, viscosity index improvers, oxidation inhibitors, oiliness agents, and materials for enabling the oils to stay in place and stand up under extreme pressure conditions. The development of these addition reagents has called for great ingenuity in the application of chemical and physical principles.

High molecular weight lubricant hydrocarbons have been made by polymerizing olefin hydrocarbons from cracking, using metal halide catalysts such as aluminum chloride.

After experimenting with an enormous number of additives for lowering the pourpoint of wax-containing lubricants, a condensation product of chlorinated wax and naphthalene known as parflow was developed that permits a controlled depression of the freezing point, and the inclusion of paraffin wax, which actually improves the lubricating properties of the oils at the high temperatures encountered by oil films in automobile engine cylinders.

Specific prepared compounds of the most diverse character are used to improve the viscosity index of lubricants; these include high molecular weight olefin polymers, resins, acids, and esters.

The oiliness of the lubricant may be measured in terms of the tenacity with which it adheres to bearings, particularly under high pressure conditions. Many types of reagents have been used to increase this property. High molecular weight aliphatic acids such as oleic have been used and also mildly oxidized vegetable oils. In the case of lubricants employed at extremely high pressures, compounds containing sulphur and phosphorous have been added to cause mild corrosion of bearing surfaces and a consequent smoothing effect.

Oxidation inhibitors (in lubricating oils) include naphthols, naphthylamines, aniline derivatives, and sulphur compounds.

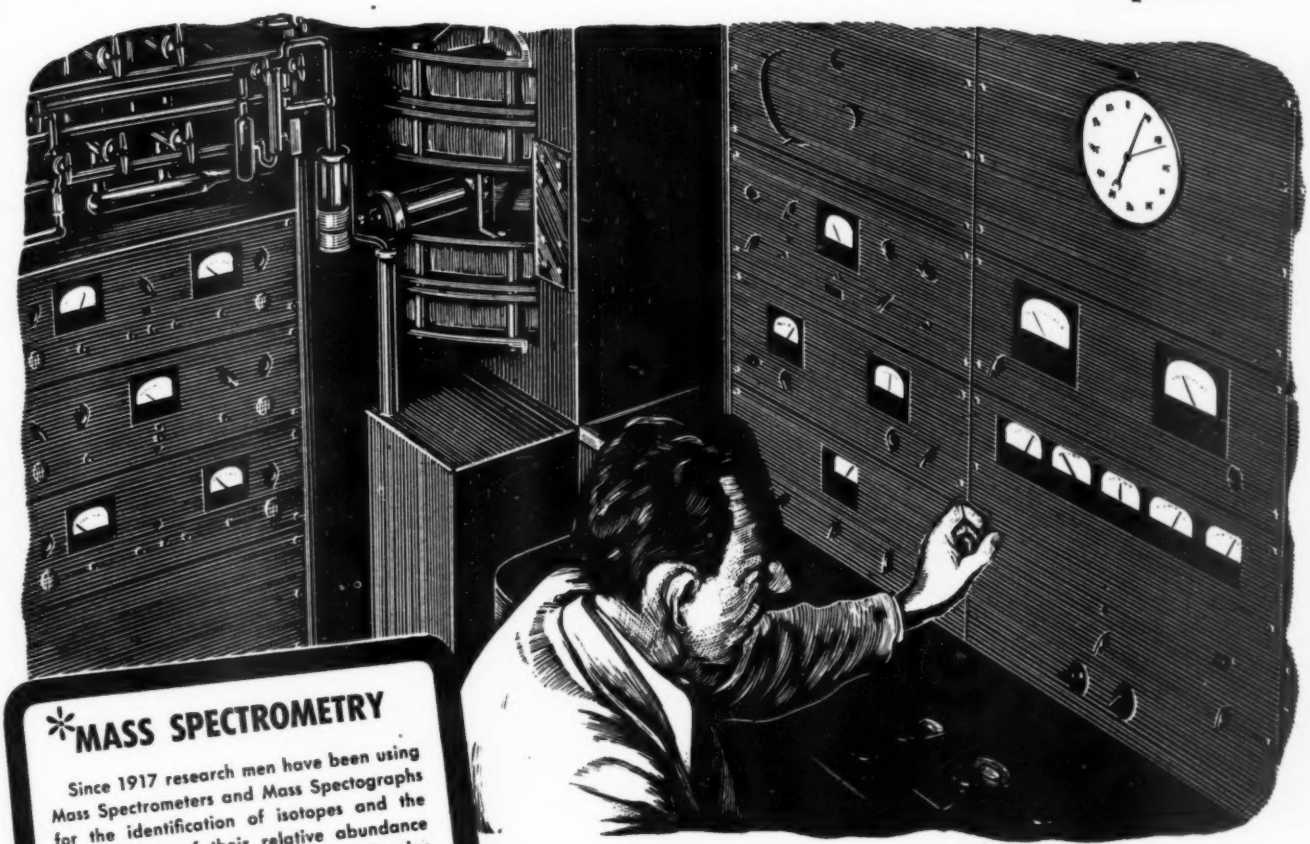
Synthetic Rubber

Alkylation of benzene with ethylene to produce ethylbenzene and then styrene by catalytic dehydrogenation is now being practiced on a large scale to produce the second compound essential to the manufacture of buna-S rubber

CONSOLIDATED ENGINEERING CORPORATION

*Mass Spectrometer**

A *new* tool for analytical control, research and development



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It remained for Consolidated Engineering Corporation, however, to develop the first Analytical Mass Spectrometer designed for general industrial use. The research program of many years which culminated in the Consolidated Mass Spectrometer was carried on by a staff of experts noted for their work in similar fields and was aided in a large measure by the cooperative work of eminent physicists and engineers.

Consolidated's research staff is continuously engaged in the development of new applications of the mass spectrometer and of new techniques in its use. For this reason, the Consolidated instrument, now operating in leading refineries and laboratories, is offered under an agreement that assures customer participation in future developments.

THE Consolidated Mass Spectrometer is an electronic instrument for the *qualitative* and *quantitative* analysis of complex gaseous or liquid mixtures. Samples of 0.1 cc liquid or 10 cc gas including as many as fifteen components can be analyzed by this instrument with a remarkable degree of accuracy. Contrasted with the many hours and even days required for the accurate analysis of such mixtures by customary chemical methods, most samples are analyzed completely in a half hour to two hours by Mass Spectrometer technique.

Under war-time restrictions the mass spectrometer is now being applied specifically to the analysis of charge-stocks and feed streams in the manufacture of high octane aviation gasoline and synthetic rubber, providing a superior control that permits far more efficient plant operation. One user of the Consolidated Mass Spectrometer analyzed over 200 samples in two weeks, and reports that within six months sufficient savings were made in plant operation to pay for the instrument.

Unlimited possibilities for the development of new products and for the designing of more effective control techniques are available through the use of this new industrial tool.

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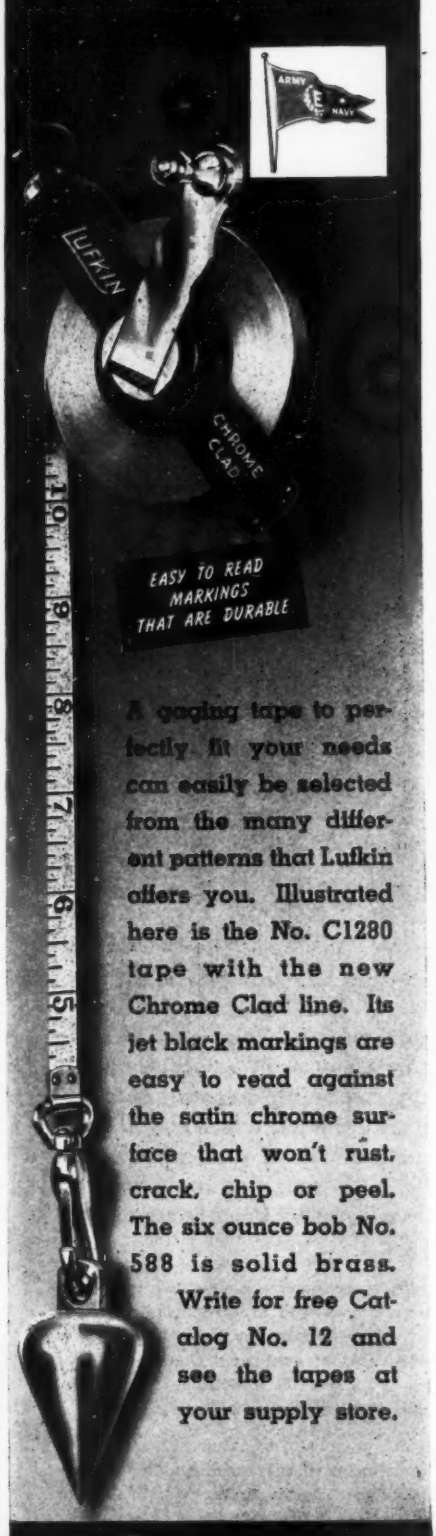

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needed in such large quantities for military and civilian uses. The butadiene is produced by the catalytic dehydrogenation of normal butylenes and butane, and from ethyl alcohol. The present national synthetic rubber program calls for an annual production of 735,000 tons of buna-S rubber. *Iso*butylene is derived from the catalytic cracking process and polymerized with pentadiene to make butyl rubber.

Other Chemical Derivatives

The number of derivatives producible from petroleum is almost unlimited, and its utilization for the production of individual hydrocarbons and their derivatives is scarcely touched. In the face of increased demands for motor and aviation fuel, the need for better utilization of natural hydrocarbons and their derivatives will continue to increase. Present processes employed in synthesizing a relatively few hydrocarbons will undoubtedly prove to be a great stimulus and incentive for developing other processes and other special hydrocarbon products. The petroleum chemist is already in the business of producing hydrocarbons in the motor fuel field and has commercialized processes for manufacturing *iso*octane, cumene, dixane, neohexane, benzene, and toluene. A single advertisement recently listed 13 pure paraffins, 7 olefins, 2 naphthenes, 2 aromatics, and 1 diolefin as available to the trade in quantity.

The present successes in synthesizing hydrocarbons from petroleum will undoubtedly lead to the commercialization of other processes now on the industrial threshold. A large number of chemical derivatives have been produced on a small scale and only await increased commercial demands to make their manufacture feasible. Already sulphuric acid is being made from the hydrogen sulphide and mercaptans present in sour hydrocarbon gases. The business of manufacturing nitro-paraffins is on a commercial scale, these compounds being useful as special solvents, as combustion accelerators in diesel fuels, and as intermediates for use in further syntheses.

Ethylene from cracked gases is being used for the manufacture of ether, alcohol, acetaldehyde, ethylene dichloride, vinyl chloride, dichlordiethyl-ether (chlorex), and glycol. Ethylene is also being marketed for use in the ripening of various fruits.

Propylene has served as a basis for the manufacture of *iso*propyl ether, a compound of high antiknock value in hydrocarbon blends and as a source of glycerin by a step-wise addition of hydroxyl groups. *Iso*propyl alcohol from propylene has found extensive commercial use as a solvent, as a denaturant and as an intermediate for the manufacture of other compounds. Allyl alcohol made from petroleum has recently been found to be an effective sleep-inducer for fagged out army pilots. The manufacture of glycerin from propylene makes possible increasing our supply of fats, and of nitroglycerin, useful both in wartime and peacetime projects.

The synthesis of cyclopropane has provided another type of anesthetic.

The number of possible chemicals derivable from petroleum is larger than that producible from coal tar, which has been the source of dyes, pharmaceuticals, and a host of other products for at least half a century.

The field of synthetic resins and plastics is engaging the attention of petroleum chemists more and more. The unsaturated and aromatic hydrocarbons available from cracking and dehydrogenation processes will be base materials for building up the high molecular weight compounds characteristic of these substances.

The petroleum industry will continue to produce increasing amounts of such products as rust-preventives, insecticides, fungicides, and various inhibitors and additives for gasoline, diesel fuels, and lubricants.

In the commercialization of various chemical processes the petroleum industry is solving many chemical engineering problems and developing metals and packing materials to handle liquids and gases corrosive to ordinary materials.

Catalysts

One of the lines of research being prosecuted intensively at the present time is the manufacture of special catalyst composites useful in various types of hydrocarbon conversion processes and in the production of chemical derivatives of hydrocarbons. Intensive studies are being made of process variables in the manufacture of catalysts for cracking, dehydrogenation, hydrogenation, alkylation, and isomerization processes. In this field the petroleum industry is expanding far into the chemical process field.

Summary

The field of petroleum as a chemical industry is practically unlimited in its future possibilities. The hydrocarbons and chemical derivatives in commercial production at the present time are principally obtained from the lower molecular weight hydrocarbons in gases and the lower boiling fractions. As the research chemist and chemical engineer continue their work and find out more about individual hydrocarbons present in the higher boiling fractions, remarkable advance in the production of petroleum chemicals will be made.

—— ☆ ☆ ☆ ——

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LARGEST PRIVATE PRODUCER OF BUTADIENE TYPE

Synthetic Rubber

Wilshire Refinery Expansion Is Aid to War Effort

PETROLEUM ENGINEER Exclusive Feature

☆ Capacity of completed 100-octane plant double that first planned

by W. D. Smith
Wilshire Oil Company, Inc.

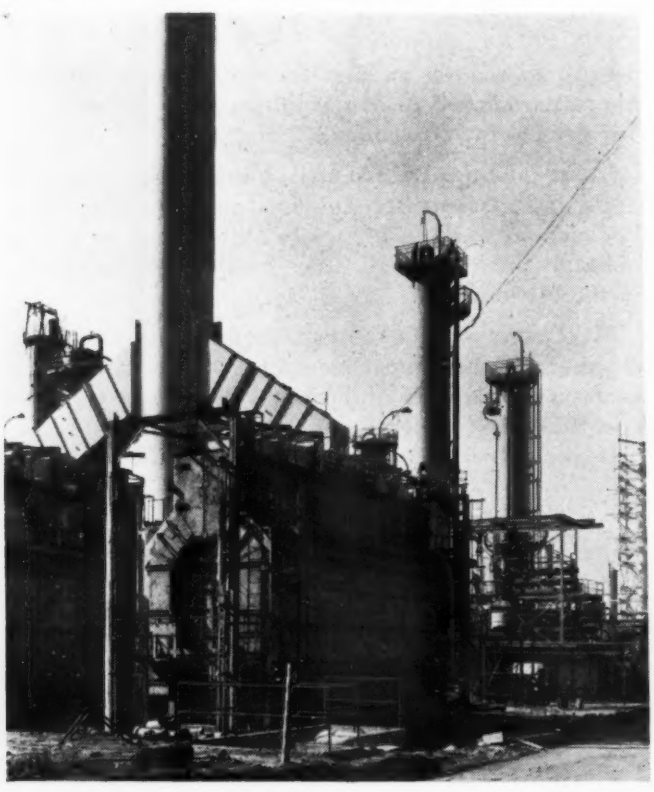
THE new 100-octane plant built adjacent to the existing refinery at Norwalk, California, is Wilshire Oil Company's most recent contribution to the war program. Although construction of this plant was not begun until December 7, 1943, just two years to the day after Pearl Harbor, changes in design of units then in operation and additions to plant facilities had already been the means of supplying specific products for use of the armed forces within a short time after the United States entered the war. The development of facilities in the refinery since its inception made this readily possible.

The first Dubbs cracking unit at the Norwalk refinery had hardly been put on stream in 1936 when it became evident that a polymerization plant was necessary to utilize the refinery gases and thereby obtain a higher octane gasoline. This necessity resulted in the construction of the U.O.P. catalytic polymerization unit, which was completed by the end of the first year of operation of the Dubbs unit. It produced polymer, which was blended with the naturally high-octane cracked gasoline to make a motor fuel higher in anti-knock qualities than ordinary gasoline. It was then realized that, in order to round out the refinery operations and increase the yield of higher octane gasoline, it would be necessary to install a reformer unit. A reformer unit was therefore placed in operation in 1938. This provided a greater quantity of natural anti-knock gasoline and an increased quantity of desirable gases for processing in the polymerization plant. Other improvements followed, including the increase of capacities, installation of additional gas compressors, safer and more efficient operation, and the installation of an ethyl blending plant.

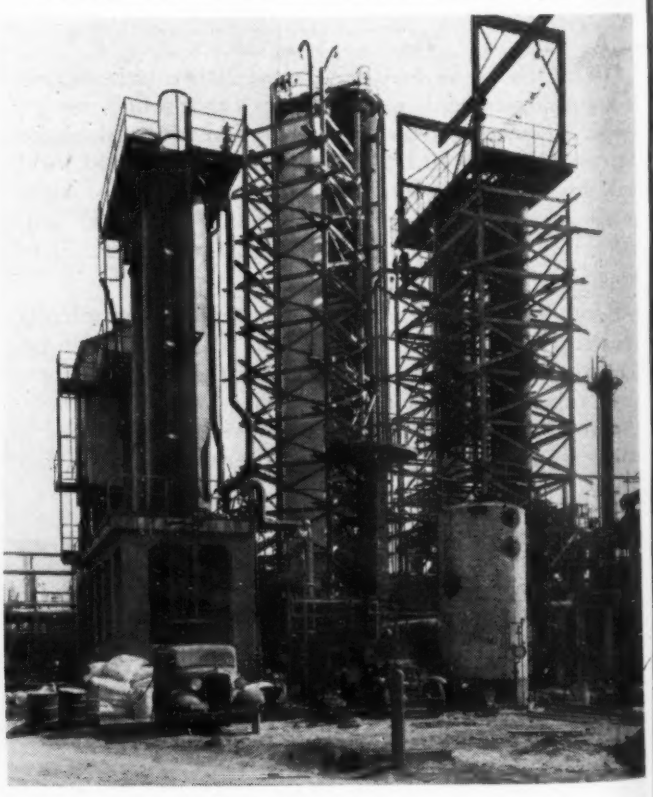
W. D. SMITH

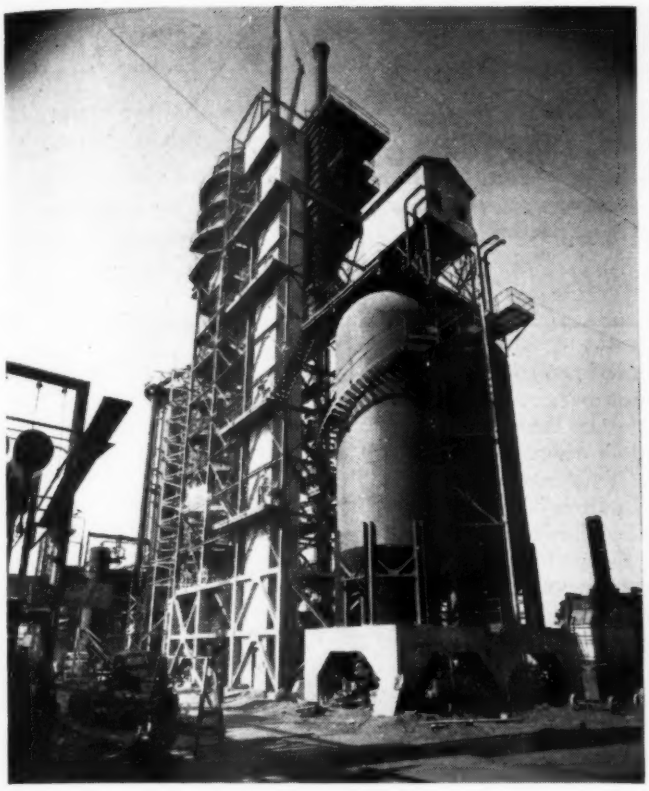
Within a few months after the advent of war the Wilshire technical staff, in collaboration with Universal Oil Products Company, had made preparations for the design of additions to existing facilities for the production of 100-

Reformer unit cracking furnace with crude oil heater at left

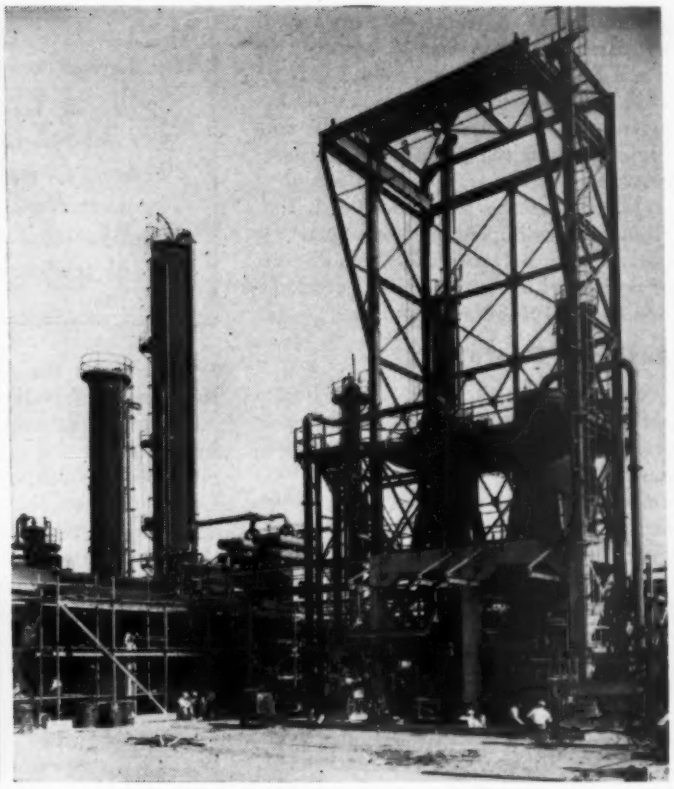


Isomerization unit reactors and fractionation equipment





Fluid catalytic cracker with catalyst hopper in foreground



Hydrofluoric acid alkylation contactor section

octane gasoline and by April, 1942, a contract was made with the Defense Plant Corporation for the erection of such a refinery at Norwalk. Immediately following this, however, the petroleum industry was called upon to furnish cumene, a component of 100-octane gasoline. The need for this material, required by the air forces in large quantities and as quickly as possible, had been anticipated; so with great speed and efficiency the polymerization plant was converted into a cumene plant. In June, 1942, just 28 days after the conversion was authorized, the plant was put on production and was the first commercial producer of cumene on the Pacific Coast.

Maximum capacity of this plant was soon obtained by development of operating technique but it was obvious that additional feed stock would be available and would necessitate expanding the unit in order to triple its original production. This expansion has been completed and has made the Wilshire refinery one of the largest producers of cumene in the West.

As one change was being planned, other alterations became necessary to supply the armed forces with increasingly needed products such as 91-octane gasoline, navy fuel oil, and materials for the manufacture of synthetic rubber. These alterations in equipment and changes in operating methods were effected with all possible speed by the refinery personnel. Meanwhile the D.P.C., the Wilshire Oil Company, Universal Oil Products Company, and Fluor Corporation, general construction contractor, were designing and building the units for the new 100-octane refinery.

100-Octane Units

In the *iso*merization plant now in service the normal butane, in the presence of aluminum chloride-hydrogen chloride catalyst, undergoes a molecular rearrangement to produce *iso*butane. The *iso*butane, a necessary constituent in the feed stock to the alkylation unit, is forced in that unit to react and combine with olefins to produce an alkylate, the chief component of 100-octane gasoline.

This reaction is based on the use of hydrofluoric acid as a catalyst, which is thoroughly mixed with the feed stock in temperature-controlled contactors. The mixture then goes to settling tanks where the hydrocarbon constituent is allowed to separate from the acid. The acid is recirculated to the process and the hydrocarbon is passed to fractionating units where unreacted constituents and undesirable components are removed. The unreacted constituents are circulated to extinction.

The choice of base stock is a vital factor because the manufacture of 100-octane gasoline requires the blending of various components to secure a balanced product. To obtain maximum production of the proper quality and balance, catalytic base blending materials are highly desirable. One of the characteristics that make the catalytic base stocks desirable is the aromatic content.

The fluid catalytic cracking method is the one used for obtaining these characteristics of the base stocks at the Wilshire 100-octane plant. A basic fundamental of the process is the introduction of a powdered catalyst into the oil stream, the catalyst being held in suspension by the recirculation of hydrocarbon gases through the mixture. Cracking of the feed stock is conducted at low pressure and relatively high temperature.

The cracked mixture, with the catalyst remaining in suspension, is sent to the fractionation column where the hydrocarbons are separated from the spent catalyst. The dry gas resulting from this separation is returned to the gas concentration unit for further treatment. The used catalyst is rendered inactive by deposition of carbon formed by the cracking reaction.

The spent catalyst goes to the regenerating unit where the carbon is burned by the introduction of controlled volumes of air. The flue gases from this system tend to carry out catalyst and thus lose it from the process. This loss is reduced to a minimum by the use of Cottrell electrical precipitation equipment. Operating in conjunction with this equipment are multiclone units. The heat necessary for the re-

generation of the catalyst is dissipated by passage of the flue gases through waste heat boilers that produce a part of the steam used in the process. After regeneration the catalyst is ready for recirculation through the catalytic cracking plant.

The use of the base stock with the alkylate, plus *iso*pentane for proper vapor pressure balance, and the addition of tetraethyl lead, result in the production of the 100-octane gasoline.

Auxiliary Operations

Controls for the 100-octane plant operation are centralized in two houses, one for the catalytic cracking unit and one for the *iso*merization and alkylation units. By means of recording instruments and gauges mounted on control panels the operators can observe and regulate from one location the temperatures, pressures, rate of flow, etc., of each piece of equipment. The recording instruments provide permanent plant records.

At a complete laboratory installed at the new plant, tests are made on all materials entering into the manufacture of the 100-octane fuel. Here each step in the refining operations as well as the quality of the finished product is controlled. One of the most important of the various analyses required is the fractional distillation of the gases entering the entire system. Analyses are made with high and low temperature Podbielniak Hyd-Robot equipment and by the infra-red spectrophotometer.

Dr. Dow Receives Gold Medal Award

The gold medal award of the American Institute of Chemists for 1944 was presented to Dr. Willard Henry Dow, president of Dow Chemical Company, at the annual meeting in New York this month. The award was made to Doctor Dow for his work in manufacture of magnesium sufficient to produce thousands of airplanes, and enough styrene to supply the needs for synthetic rubber.

Blending of the various components to specified octane numbers requires considerable technique and is controlled by the use of test engines designed and built for this purpose. Two engines of different design and requiring different operating technique are employed to obtain information on the performance of a fuel under operating conditions that approach actual flying conditions as closely as possible.

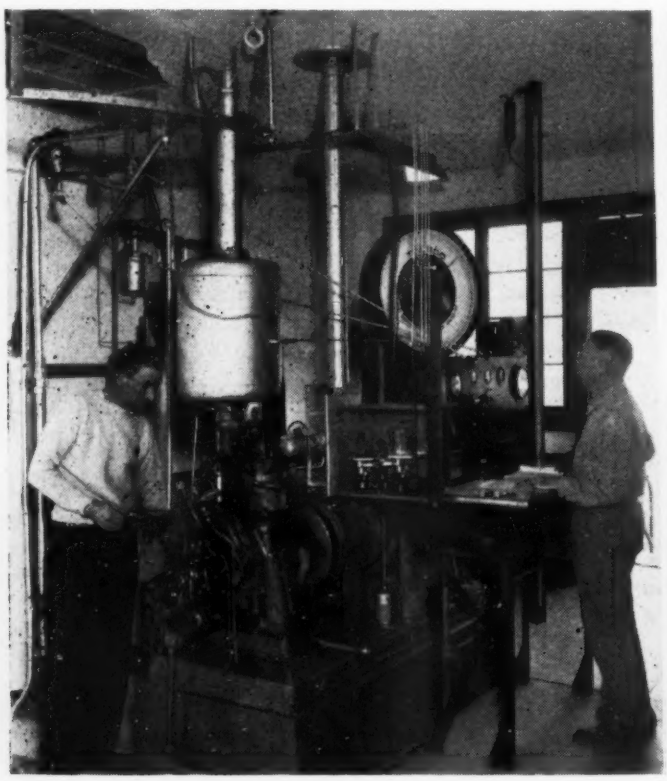
Pressure storage for feed stock and blending agents is provided by two 3000-bbl., 85-lb. per sq. in., and one 3000-bbl., 30-lb. per sq. in. pressure Hortonspheres. Total storage capacity is approximately 500,000 bbl., which is utilized for rundown and blending stocks and for storage of finished products.

Two Foster-Wheeler boilers with capacity of 250,000 lb. of superheated steam per hour were added to the existing steam generating plant for operating the 100-octane installations. A turbo-generator plant consisting of three 1000-kva. Westinghouse generators furnishes the electric power. Two of the generators operate on 10-lb. exhaust steam and the other, acting as a standby, operates on 150-lb. steam. Condensing is at sub-atmospheric pressure for maximum efficiency.

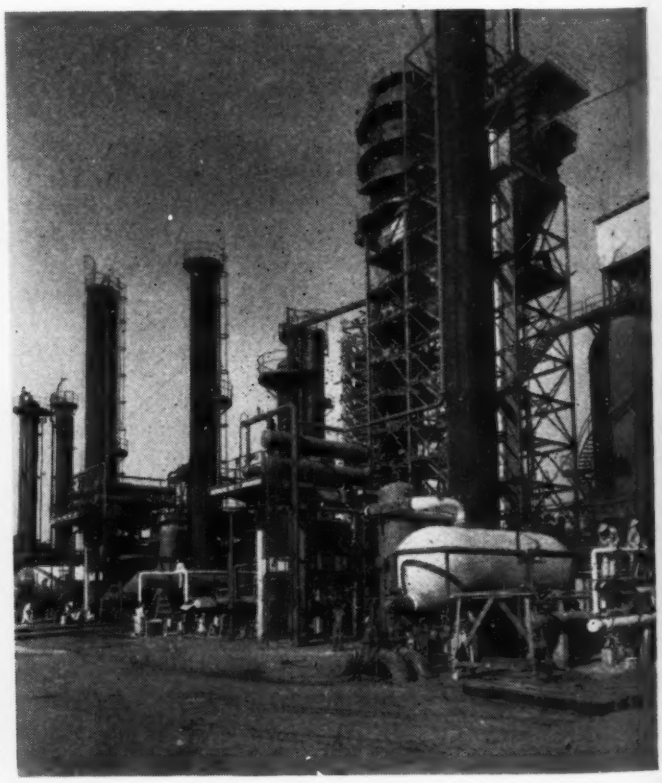
The cooling equipment consists of one Fluor Model 60-A-15 aerator cooling tower, which has a capacity of 10,000 gal. per min., cooling from 120° F. to 90° F. with wet bulb at 75°, and a relative humidity of 40 per cent. This operates in conjunction with the previously installed water cooling system.

The capacity of the completed 100-octane gasoline refinery is double that planned at the time construction began. The increase is due to data obtained from similar plants previously placed in operation, to changes made in some of the cracking units, to finding and removing bottlenecks, and to improving the operating technique by the company's engineering and operating personnel. ☆☆☆

Testing 100-octane gasoline



Gas concentration section



California's 100-Octane Program—A Factor in Global War

PETROLEUM ENGINEER Exclusive Feature

☆ Refinery expansions to increase aviation gasoline output near completion

by Wallace A. Sawdon

Pacific Coast Editor

THE great efficiency and superior performance given to bombing and combat planes by 100-octane gasoline made a tremendous and speedy expansion of refining facilities for the manufacture of such fuel imperative upon the entry of the United States into war. Of vital importance was the location of sources of supply on the west coast to take care of the ever-increasing demands of Pacific operations.

These demands had to be met by California refiners who immediately inaugurated a program for construction of additional plants while taxing to the utmost the existing facilities for the production of 100-octane gasoline. The output of aviation gasoline has increased rapidly as units have been put into operation; and at the present time the entire 100-octane gasoline program is nearing completion.

The California 100-octane gasoline expansion and new construction program extends from the Los Angeles area to the San Francisco Bay region. The extent of the program could best be indictated by capacity in barrels per day but, as this cannot be given, some idea of the program can be gained from consideration of the money expended on equipment and construction. Estimates place the expenditure for refinery expansion in California as caused primarily by war requirements at nearly $200,000,000 and it is interesting to note that the money spent was largely provided by refining companies. The program necessarily included the revamping of some existing facilities to meet the requirements of new processes and designs and also increased the productive capacity for other refined petroleum products, which in themselves are contributions to the war effort.

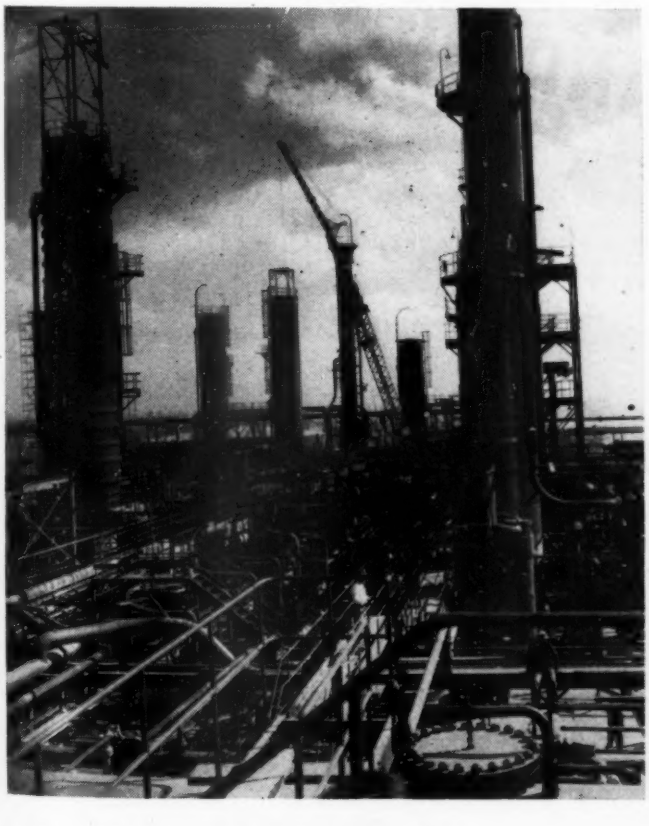
Construction work was unavoidably obstructed at times by shortages of materials and manpower but completion of plants has progressed rapidly despite such delays. In some cases plants originally designed for the manufacture of different grades of gasoline or of other products were redesigned during construction to increase the output of 100-octane fuel. A summary of some of the important installations follows.

Standard of California

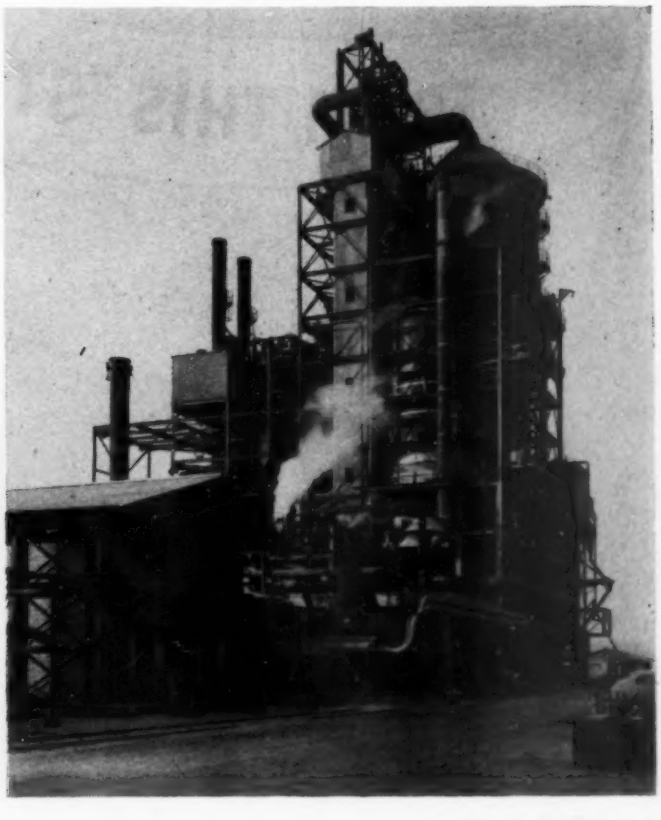
Before the war Standard Oil Com-

(Continued on Page 124)

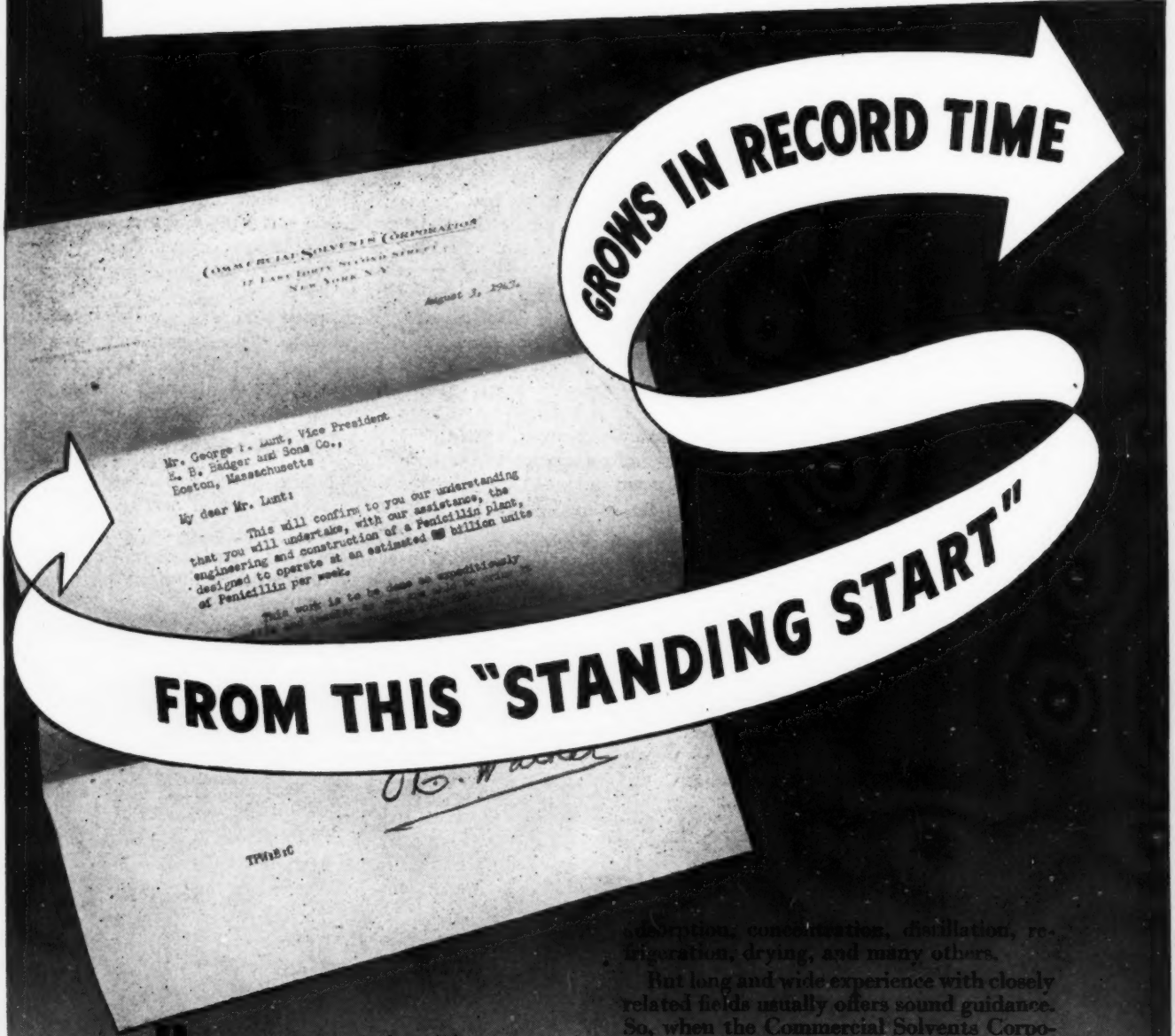
Fractionating towers of combination cracking unit at Union Oil Company's new 100-octane plant



The 240-ft. tower of Shell Oil Company's new catalytic cracking plant near Wilmington



WORLD'S LARGEST

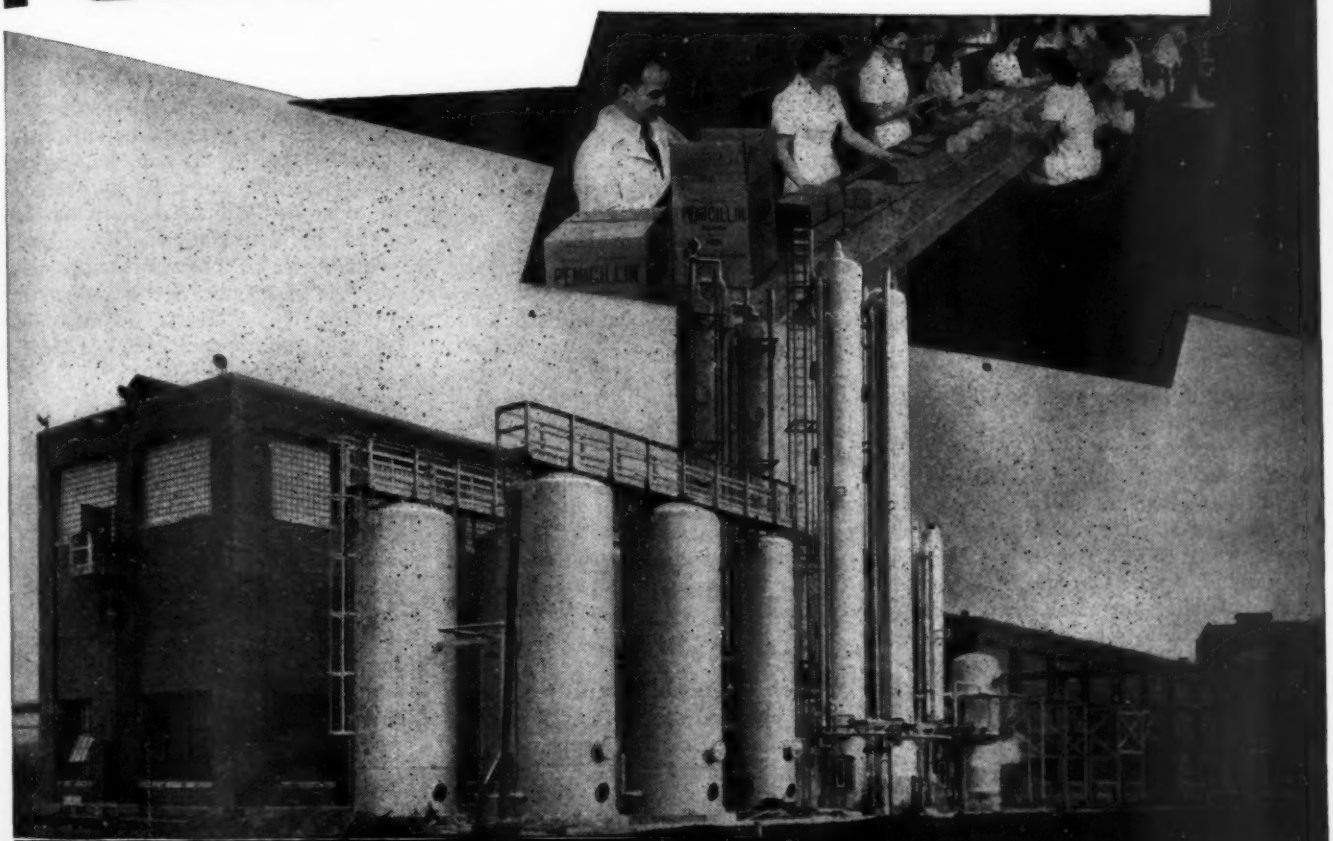

GROWS IN RECORD TIME
FROM THIS "STANDING START"
Mr. George T. Lunt, Vice President
E. B. Badger and Sons Co.,
Boston, Massachusetts
My dear Mr. Lunt:
This will confirm to you our understanding
that you will undertake, with our assistance, the
engineering and construction of a Penicillin plant,
designed to operate at an estimated [redacted] billion units
of Penicillin per week.

PENICILLIN . . . priceless life-saving aid to humanity! So new is this wonder drug that when war-emergency demanded large-scale production quickly, there was little precedent on which to base manufacturing requirements.

Never before in our experience were process engineers faced with such a variety of problems to be solved in so short a time—problems of extraction, filtration, adsorption, concentration, distillation, refrigeration, drying, and many others.

But long and wide experience with closely related fields usually offers sound guidance. So, when the Commercial Solvents Corporation sought process engineering and construction services for a plant "*designed to operate at an estimated* (censored) *billion units of Penicillin per week,*" to be completed "*as expeditiously as possible,*" it was the highly qualified Badger organization that was selected to handle the entire project in co-operation with the Research and Engineering Departments of Commercial Solvents Corporation.

PENICILLIN PLANT



Because Penicillin is a sensitive product, and its efficacy is dependent on many critical factors of production, this achievement, for speed and intricate details, completely overshadows the work of average

It is the sum of diversified and cumulative experience in process engineering, equipment designing and plant construction that enables Badger to handle new and unusual projects of any size, anywhere in the world.

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Process Engineers and Constructors for the Chemical, Petroleum and Petro-Chemical Industries

(*Continued from Page 121*)

pany of California was making 100-octane gasoline but its output of this product is now about three times what it was then. Moreover, expansion is still in progress and within the next 6 to 8 months 100-octane gasoline production from its Richmond and El Segundo refineries will probably be one-third greater than at present.

Refinery construction that had been started immediately preceding the war included a hydrogenation plant, two alkylation plants, two *iso*merization plants, and a Houdry catalytic unit. The Houdry unit was originally designed for manufacture of both 100-octane and other grades of gasoline but because of the advent of war before its completion the design was changed to increase the 100-octane capacity to meet the greater demands for aviation fuel. The two alkylation plants were completed prior to the war but the one at Richmond has since been enlarged 50 per cent and the one at El Segundo has had its capacity trebled.

In addition to new units at its Richmond refinery, Standard has converted its toluene plant to the production of aviation gasoline for the duration. This change-over from explosive ingredients to gasoline production was made in a very short time, the quick change being possible because the process used for the manufacture of toluene was similar to that employed in the production of 100-octane gasoline.

The toluene process and its catalyst were developed by Standard Oil Company and the catalyst, made at the refinery in a special unit designed for the purpose, is now being used in the production of the high octane gasoline in the converted plant. As was the case when making toluene, the charging stock is heated and vaporized in tubular-fired furnaces where the fluids are raised under high pressure to a temperature of approximately 1000° F. The resulting gases then go to reactor chambers containing the catalyst and here a high test gasoline is formed. This product then passes through a series of four distillation units for separation before final blending.

A new and separate Defense Plant Corporation 100-octane plant is now under construction at Richmond. In this plant there will be 2 Thermofor catalytic cracking units treating gas oil for high octane blending stock and such by-products as butanes and *iso*butane. These will go to an alkylation plant for production of alkylate gasoline to be used for the 100-octane product. At the same time normal butane will be converted into *iso*butane for the alkylation process in an *iso*merization plant developed by Standard. The base stocks will be blended with straight run gasoline for production of finished 100-octane fuel.

Union Oil Company

A new Union Oil Company plant recently put into operation at Wilmington has increased that company's output of 100-octane gasoline more than 600 per cent. The additional facilities have, moreover, increased the average yield of gasoline from all crude processed in Union's refineries to 44 per cent.

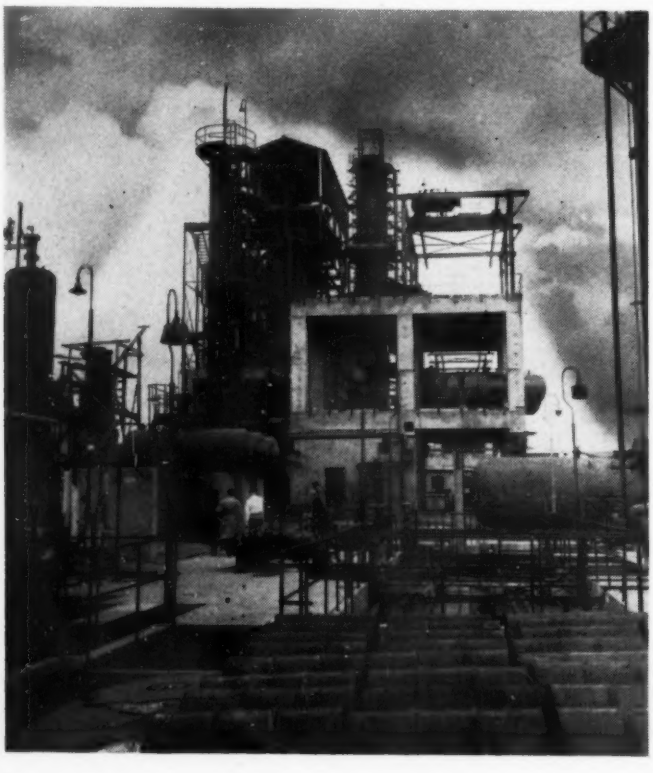
Included in the new plant is a combination distillation and catalytic cracking unit. The cracking unit is approximately the height of a 20-story building and is equipped with an elevator to carry operators to the various levels.

The flow of oil in the new plant is continuous and the design eliminates tank storage for different compounds between processes. All main streams are controlled from one point and smaller units are fed by the combination unit. From the time the crude oil enters the heaters until final fractionation each barrel has been pumped from place to place with a total circulation equivalent to that of 20 bbl. Products recovered include: Diesel fuel, and stove oils; toluene stock; motor fuel, and aviation feed stock.

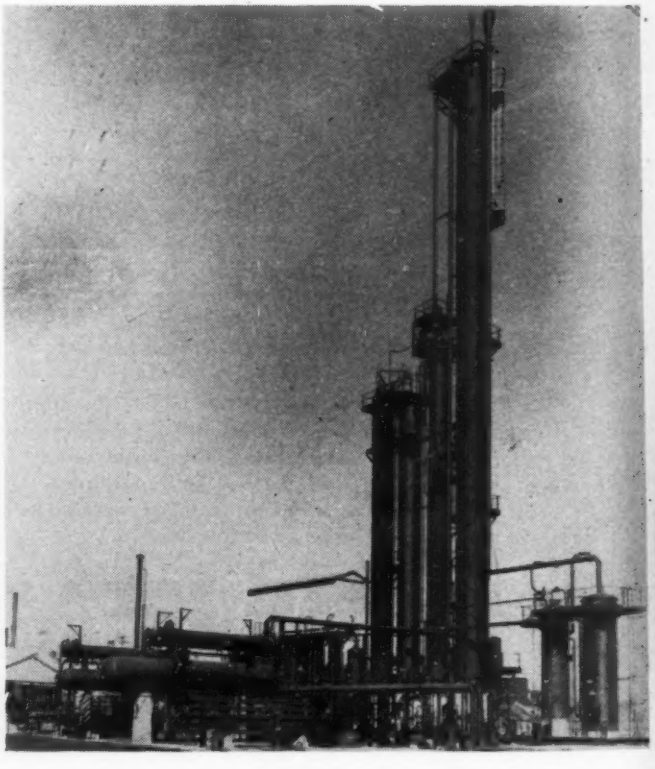
General Petroleum Corporation

Among the recently completed 100-octane plants is that of General Petroleum Corporation at Torrance. Careful preplanning of the process and operation in this plant was carried out to make sure that upward revision of quality requirements could be made. The Thermofor continuous catalytic cracking process is used in the new installation. A gas plant processes all the refinery gases for recovery of butanes and *iso*butane and these are reacted in a

Catalytic reactors and auxiliary equipment in Union Oil Company's new isomerization unit



Standard of California's isomerization plant at El Segundo converts normal butane into isobutane



hydrofluoric acid alkylation unit. Although the gas plant and the alkylation operations are of the more-or-less conventional type, the alkylation unit is one of the first in California to employ hydrofluoric acid.

At the present time there are two Thermofor units with capacity of 10,000 bbl. per day each in service for gas oil charge. These are to be duplicated and are expected to be in operation within two or three months. When these new units are completed the gas oil will be processed in two of the units and the first-pass gasoline in the other two. This method is to be used to insure both maximum quantity and highest quality of the catalytic base stock for the production of finished 100-octane gasoline blend. The volume of alkylate usually being the limiting factor in blending to 100-octane gasoline specifications, General Petroleum believes that the large volume of high quality base-stock producible by this plant will effect a more economical use of aviation alkylate than, in the normal case, will the use of straight run base stock.

Shell Oil Company

Shell made the first 100-octane gasoline in 1935 and its new catalytic cracking unit at Dominguez was the first of its kind that had been started after the declaration of war to be completed in the country. This plant is now producing stock for the manufacture of 100-octane fuel and is one of the main units of the 100-octane plant. The catalytic cracking unit is 240 ft. in height and required approximately 18,000 tons of steel in its construction. Other units in the new 100-octane plant are those for alkylation, butane *iso*merization, pressure hydrogenation, and product fractionation.

Tide Water Associated

Additional facilities for the production of 100-octane gasoline are now being installed at the Avon refinery of Tide Water Associated Oil Company. Completion is expected within the next few months. Included in the expansion program are a catalytic cracking plant, butane and pentane *iso*merization units, superfractionation columns for distillation units producing natural gasoline and gasoline from the crude; a solvent refining plant, and an alkylation plant. Sulphuric acid will be used in the alkylation of butylenes, amylenes, and propylenes.

The Texas Company

Also nearing completion are additions to The Texas Company refinery at Wilmington. The expansion program here includes a cracking unit, increased alkylation capacity, and greater steam generation capacity. The work now in progress is being done by Foster-Wheeler Corporation, M. W. Kellogg Company, and Bechtel-McCone-Parsons Corporation.

Richfield Oil Corporation

Richfield's refinery at Watson has a Thermofor catalytic cracking unit under construction. The expansion program that will soon be completed comprises increased alkylation capacity, new fractionating installations, and auxiliary facilities. The work is being done by Lummus Company.

Mohawk Petroleum Corp.

The Mohawk Petroleum Corporation began negotiating with Universal Oil Products Company for the construction of a small alkylation plant shortly after the outbreak of war in Europe in 1939. The Pearl Harbor incident hastened and enlarged the original plans. On October 26, 1942, ground was broken on the 20-acre site of the 100-octane plant. The plant was fully completed on March 1, 1944, after an expenditure of several millions of dollars. Actual process operations, however, were started the January before. The reformer and gas concentration units were first on stream followed by the *iso*pentane splitter unit, alkylation unit, and finally the *iso*merization unit, which was brought into operation during the month of March.

Several process changes were made during construction. The operation of similar plants throughout the country developed process improvements that were incorporated into this plant.

The power plant of the 100-octane refinery supplies steam for the various pumps, turbines, and heating throughout the area. The feedwater is treated with sodium exchange bases and by hydrogen exchange bases, the effluent from the treaters being blended and degasified followed by de-aeration. Three low pressure marine boilers and one high pressure boiler make up the boiler equipment of the power plant.

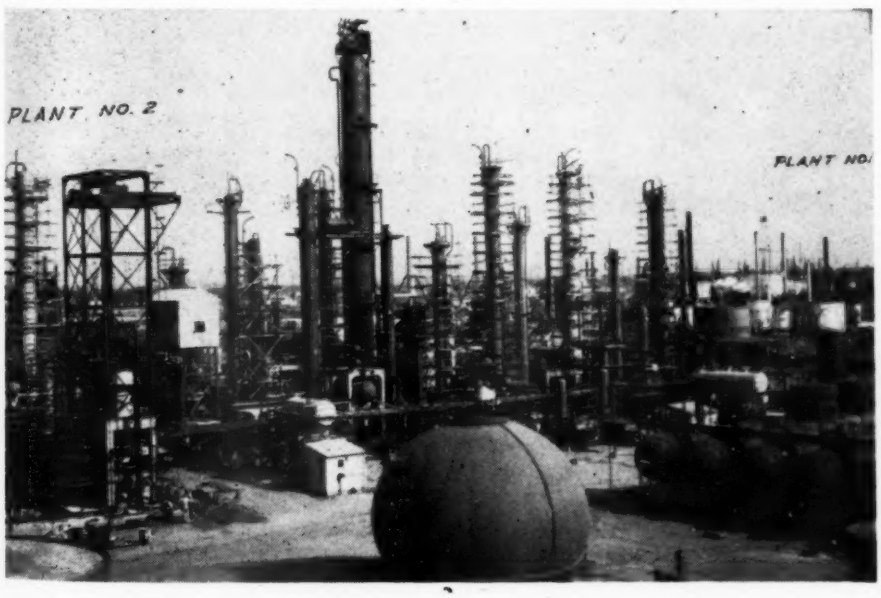
There are a large number of vessels, tanks, exchangers, pumps, compressors, heaters, and buildings of various sizes throughout the 100-octane plant. A complete machine shop takes care of maintenance work and a well equipped instrument department maintains operations of the all-important control instruments.

Control work is maintained by a complete laboratory, including low temperature and high temperature Podbielniak apparatus and infra-red spectraphotometer. The knock engine laboratory is equipped with the latest type knock engines.

The production of 100-octane aviation gasoline from Mohawk's new facilities depends on the preparation of a selected feed stock from which the blending component known as alkylate is made, and the precise fractionation of straight run gasoline to produce the remaining components.

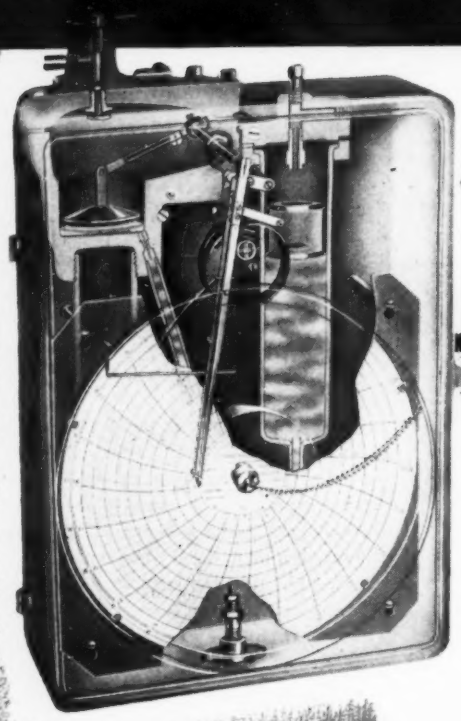
In the new plant there are 4 more or less interconnected units that perform the above operations. The reforming unit makes the butylene and amylene necessary in the alkylation reaction. The gas concentration unit refines the crude butylenes and amylenes to rid them of undesirable light and heavy components. The *iso*merization unit makes *iso*butane, also necessary in the alkylation reaction. The alkylation unit combines the *iso*butane, butylene, and amylene to produce alkylate. The *iso*pentane splitter separates casinghead gasoline into a residual straight run gasoline, normal butane, and *iso*pentanes,

(Continued on Page 130)



Mohawk plants at Bakersfield. Plant No. 1 is the old refinery. Plant No. 2 is the new aviation gasoline plant

Standard AMERICAN *meters fit the mo*



SIMPLICITY OF DESIGN and proven reliability of ope tion dictated the choice of AMERICAN flow meters for this foremo aviation gasoline plant. They are our standard orifice meters, remo pressure recorders and flow controllers.

Many thousands of these same meters are in operation in refiner around the globe . . . including South America, where simplicity an ease of adjustment and maintenance are of critical importance.

They have only one moving part between the mercury surfa and the chart record.

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With each increase in emphasis upon instrument control an smaller crews of experienced personnel in refinery processes, th AMERICAN principles of design assume greater importance.

We shall be glad to send you engineering data describing the in detail.

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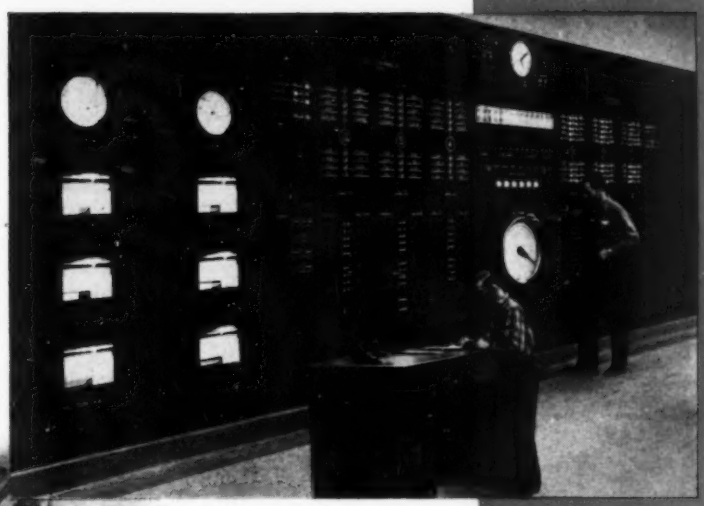
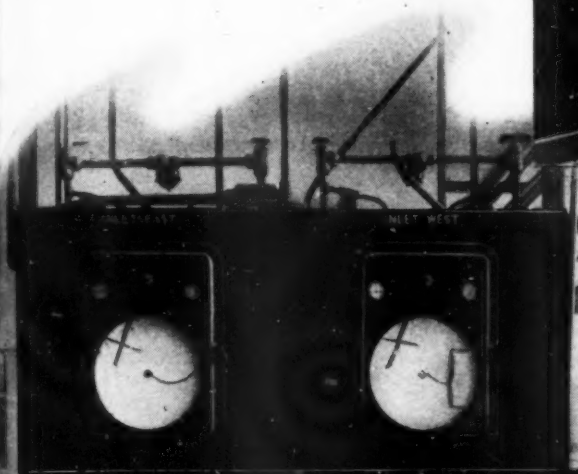
...advanced processes at Marcus Hook!

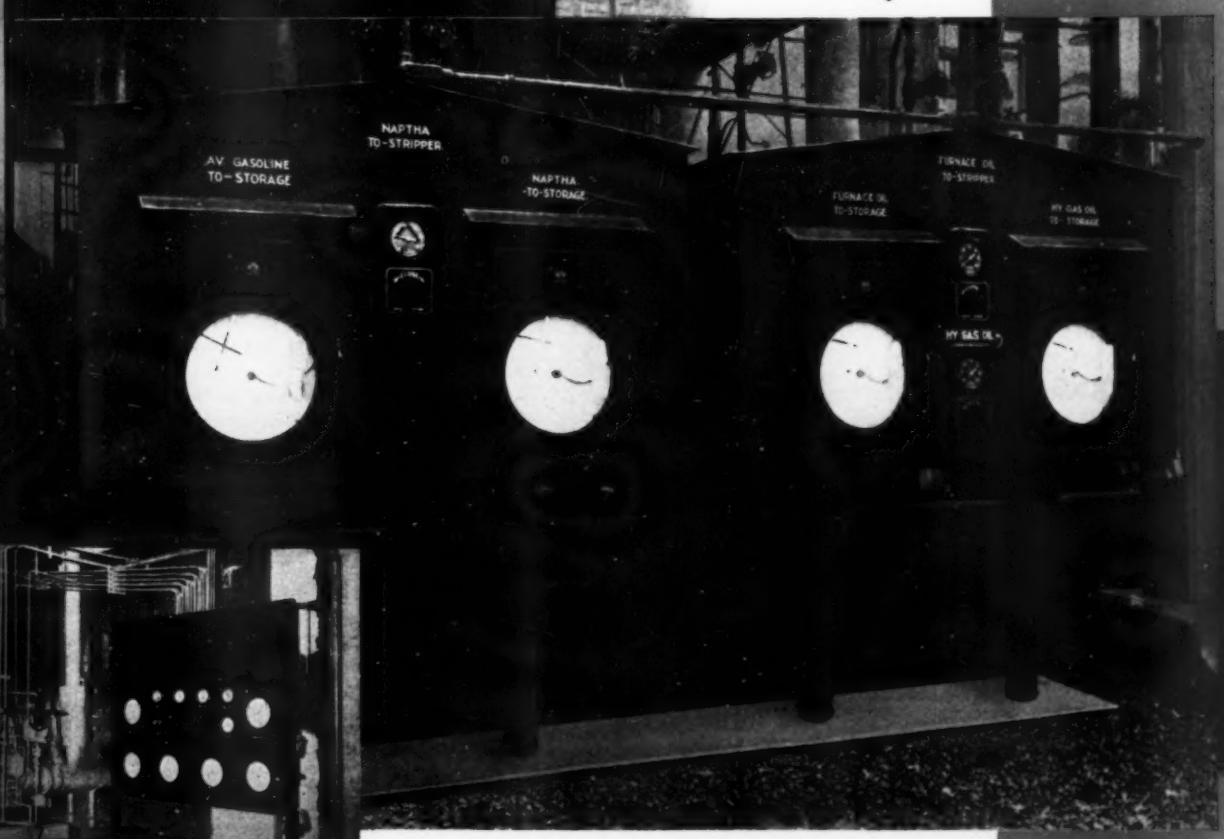
Main control board of Houdry unit at Sun Oil Company's aviation gasoline refinery, Marcus Hook, Pennsylvania. At the upper left are the **AMERICAN** *air-actuated remote pressure recorders. Instruments of this type have enabled refinery designers to have many important records grouped together on a centrally located panel board. This principle of operation eliminates long lead lines between the orifice locations and the instrument board.* **AMERICAN** *was one of the first to design this type of instrument.*

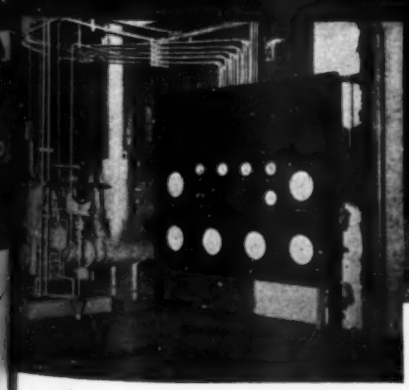




AMERICAN *inlet flow controls on charge to reboiler at the alkylation unit.*

These **AMERICAN** *flow meters are measuring products from the Houdry unit.*





On the control board at the boiler plant, another group of **AMERICAN** *flow meters.*

(Continued from Page 127)

the last being a necessary component of 100-octane aviation gasoline.

Straight run naphtha from Plant 1 is charged to the reforming unit where it is cracked under pressure and high temperature. The products from this cracking are a reformed gasoline of good octane number and light hydrocarbons. The gasoline is separated from the light hydrocarbons in the depentanizing column of the gas concentration unit, and returns to Plant 1 for use in motor fuel. The overhead from the depentanizing column contains the butylene and amylene necessary for alkylation and is charged to the depropanizer of the gas concentration system for removal of propane and lighter gases. These light gases are returned to Plant 1 for fuel and polymerization unit charge. In addition to the materials from the reformer, the gas concentration unit is also charged with light hydrocarbons from the cracking units at Plant 1 for removal of butylene and amylene. The concentrated B-B feed from the bottom of the depropanizer goes through caustic scrubbing equipment to remove sulphur and then into horizontal closed vessels for storage as alkylation plant feed.

From storage, the B-B is charged through dryers to a pair of Stratco contactors, where it is intimately mixed with *iso*butane and hydrofluoric acid to bring about the alkylation reaction. The contactor effluent goes to a settler, from which the acid is continuously recycled to the contactors. The hydrocarbon in the settler, containing alkylate, butanes, pentanes, propane, and a small amount of dissolved acid and organic fluorides is next depropanized to effect the removal of propane and dissolved acid. The dissolved acid is then stripped from the propane in the acid stripper and returned to the settler.

The depropanized hydrocarbon stream is charged to towers packed with bauxite, where the organic fluorides are absorbed.

The remainder of the operation consists of successive fractionations to remove *iso*butane, butane, pentanes, and, finally, to separate the small fraction of heavy alkylate from the aviation alkylate. Another bauxite treat is given between the de*iso*butanizer and the debutanizer.

The de*iso*butanizer overhead is recycled to the contactors, to maintain an *iso*butane-olefin ratio of 5 to 1 or better. The debutanizer overhead is stored or charged to the *iso*merization unit, to produce *iso*butane. The *iso*merization effluent, consisting almost entirely of butane and *iso*butane, is combined with the casinghead butanes from the pentane splitter and charged through dryers to the de*iso*butanizer. The depentanizer overhead is charged to the pentane splitter for separation into *iso*pentane and normal pentane. Aviation alkylate is taken overhead in the final fractionation and the heavy alkylate bottom is used as slush in pumps and controls, excess being stored or used as quench on the reformer.

The hydrofluoric acid used to catalyze the alkylation reaction becomes less effective as it is diluted with water and heavy tars resulting from side reactions. To keep the acid at proper strength, a small stream is charged to the acid regeneration system and given two fractionations. In the first, the heavy tars are removed as a bottoms product and in the second, pure acid is taken overhead and returned to the settler while an acid-water mixture of about 40 per cent strength, the constant boiling mixture for this system, is drawn from the bottom into a neutralizing pit.

Wilshire Refinery

A description of refinery installations that have just been completed by Wilshire Oil Company is given in a separate article in this issue.

—— ☆ ☆ ☆ ——

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The improved AC-ME RECORDING GRAVITOMETER has been designed with a primary consideration for accuracy which has been obtained by simple and sturdy construction.

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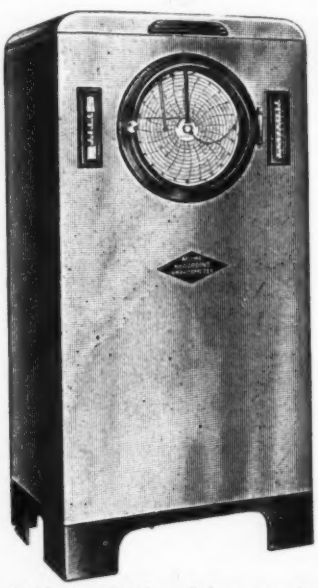

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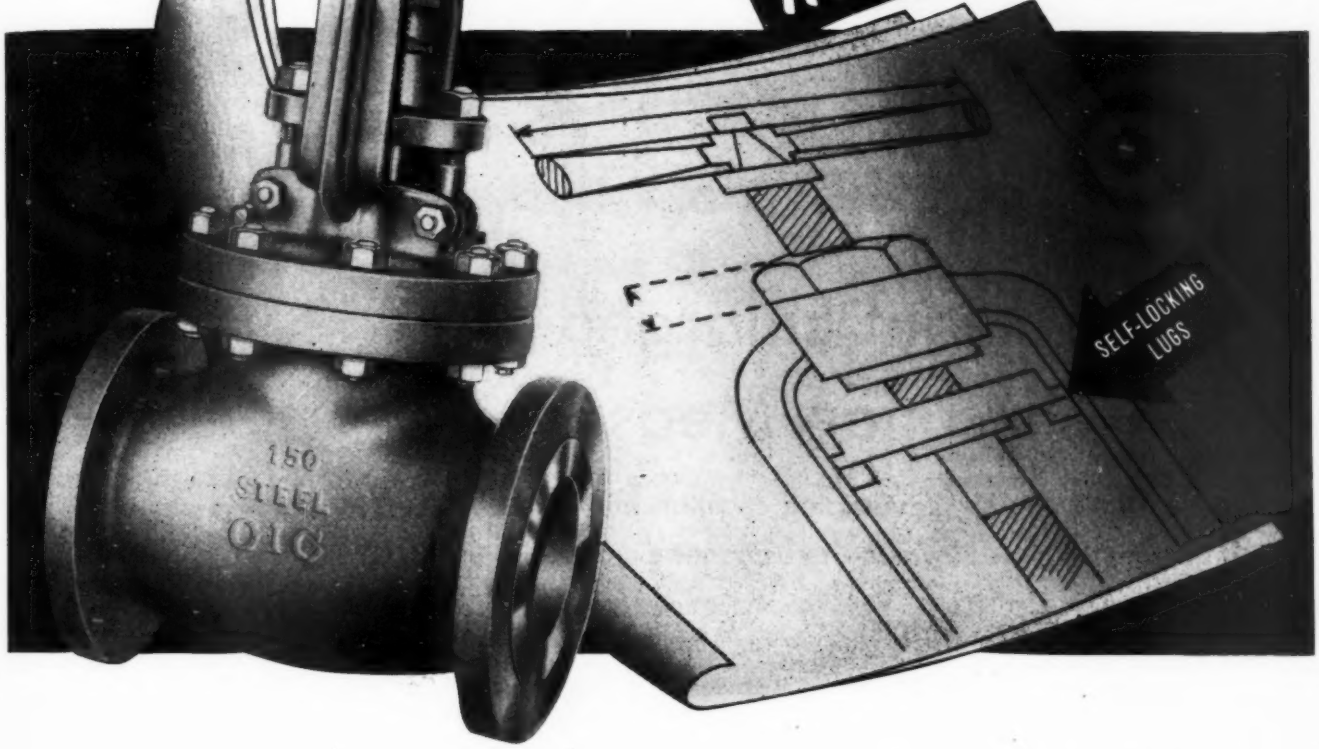

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(2) Eye-bolts holding the packing••

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Main header ditch showing suction and discharge line arrangement

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Gasoline Plant Enlarged As Conservation Measure

☆ Revamping of plant eliminates waste of casinghead gas

by Don Attaway

Superintendent of Measurement, Arkansas Fuel Oil Company

FOR the purpose of conservation and as an economic benefit derived from utilizing all available gas production rather than embarking upon an exploration or old field drilling program in the face of wartime material and manpower shortages, the Arkansas Fuel Oil Company is now expanding and enlarging its Jefferson gasoline plant, situated in Marion County, Texas, so that oil well or casinghead gas, now being flared, can be delivered into its high pressure transmission lines for distribution to domestic and industrial consumers.

The usual practice followed by casinghead gasoline plants is to flare all excess residue gas not required for the plant and field operations. During the flush period of an oil field, the casinghead or separator gas is usually processed at a natural gasoline plant where a considerable portion is converted into gasoline production with a resulting shrinkage and still more utilized for plant fuel. The remaining residue is usually required in its entirety for field lease operations and drilling rig fuel. Oftimes the field expansion is so rapid and drilling rigs so numerous that the residue gas is insufficient to meet the demand and gas must be purchased by the drilling companies from distributors or producers in the field for rig operation.

This condition only exists, however, while field expansion is taking place, and by the time the field extent is well defined and all permissible drillings completed, quite a volume of low pressure excess residue gas is being flared.

Such a condition is a waste of a natural resource and has been a considerable problem for the gas companies due to the economics involved in saving, compressing, and transporting such gas.

With the coming of the war, however, and the resulting curtailment of exploration and drilling, this waste or flare gas has become highly important and especially in those fields where the propane and butane content is high.

Consequently many of the major companies have taken steps to conserve and utilize this product.

The Jefferson area is in the Gloyd horizon of the Rodessa field and some 26 leases, having total of approximately 50 wells, are delivering about 150,000,000 cu. ft. monthly of separator gas into the company gathering system for processing at this plant.

At the present time, the plant is equipped with three 400-hp., 4-cylinder, V-type angle compressors that operate at a pressure of approximately atmosphere intake and discharge at 40 lb. An induced draft cooling tower 18 ft. by 22 ft. is erected, having a bank of 7 gas coolers in the basin of the tower. These coolers are approximately 20 ft. long and have sixty 1-in. tubes or a total of 314 sq. ft. each. After cooling, the gas is processed in a vertical 48-in. by 45-ft. absorber.

Compressor Installation

This equipment is the low pressure unit of the plant but some 13 high pressure gas wells are also in the field and the plant processes gas produced from these wells in a high pressure unit operating at approximately 400 lb. This was described in an issue of this magazine some time ago.

In order to utilize the low pressure gas, the installation of four 300-hp., 8-cylinder, V-type compressors was necessary. These compressors have two 10-in. by 12-in. low pressure cylinders and one 5½-in. by 12-in. high pressure cylinder. The low pressure stage will take suction at approximately 32 lb. and discharge at 200 lb. The high pressure

stage will take suction at 200 lb. and discharge at approximately 500 lb. These compressors have a capacity of 1,900,000 cu. ft. each per day.

The compressors will be housed in a structural steel building 85 ft. long and 32 ft. wide.

Gas cooling of the 200-lb. discharge will be accomplished by the use of 8 multi-tubular closed type shell-and-tube gas coolers, each having approximately 75 tubes, whereas the high pressure discharge gas will cool through 4 similar type coolers.

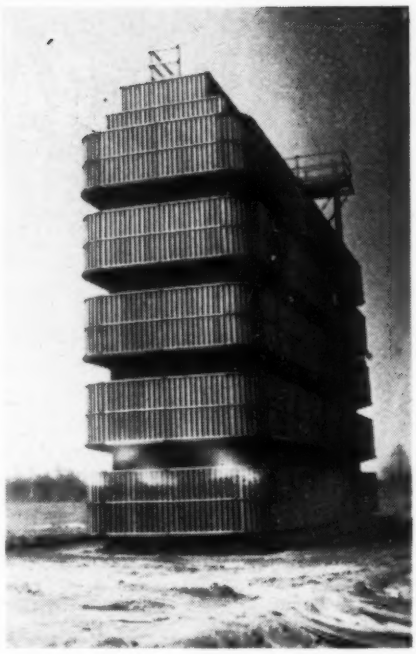
Gas Processing

Gas from the low pressure discharge of the compressors will be processed in a vertical 48-in. by 30-ft. absorber, already part of the plant equipment. After compression in the final stage, the gas will be measured and delivered into the Arkansas Louisiana Gas Company main transmission line.

For cooling water, a 5-tier aerator type tower has been erected. This tower is 45 ft. high and has eleven 6-ft. bays. It is 70 ft. long and 18 ft. wide and is fabricated from California redwood. Water is circulated through the gas coolers, engines, and over the tower by means of 2 single-stage, double-suction centrifugal pumps, each having a capacity of 1500 gal. per min. These pumps are driven by 60-hp. steam turbines operating at 2000 r.p.m.

The cooling water system for the compressors and power cylinder jackets is of the closed system type. These engines are equipped with a 34-tube cooler or heat exchanger that is placed near the base of the compressor cylinders and a small water pump on each engine circulates the water through the jackets and into the cooler tubes. Thermostatic control of the jacket water temperature is by means of a valve that admits cooling water from the tower to flow countercurrent through the cooler shell. A 50-gal. make-up water tank is mounted on the engine room wall 16 ft. high and maintains a closed system over the power cylinder jackets.

The main inlet or suction line to the compressors is a 12-in. welded line and the low stage discharge line to the absorber is an 8-in. welded line. The absorber overhead or return line to the high stage is also an 8-in. welded line. The main line return is a 6-in. welded line. In all these lines, tube turns have been utilized instead of the conventional welded 90° ell. Steel, lubricated plug valves have been installed throughout the engine piping.



End view of 5-tier aerator type cooling tower showing rounded basket type tier ends

Fuel for the compressor engines is taken from the 200-lb. absorber discharge and regulated down to 4 or 5 lb. at the engine fuel header. Extra sensitive regulators then drop the engine fuel pressure down to approximately 2-in. of water and thence into 4-ft. by 18-in. volume tanks before delivery to the engine proper.

Newest model air filters are installed to insure air purity. Each engine is also equipped with Maxim silencers.

In order to produce air for engine starting and water well blowing, considerable difficulty was experienced in procuring air compressors. As a result, an obsolete and abandoned piece of equipment was utilized; an old vertical 100-hp., 4-cylinder engine direct-connected to a 2-stage twin-cylinder air compressor was reclaimed, reconditioned, and put into service. This engine is of the enclosed type and has an unusual automatic-balanced lubrication system.

The low pressure stage has a 10-in. cylinder with an 11-in. stroke, whereas the high pressure stage has a 4⅛-in. cylinder with the same stroke. Operation has found it to be very efficient and of ample capacity when operating at 400 r.p.m. and discharging at approximately 225 lb.

In fact, the performance of this reclaimed and reconditioned engine has resulted in the company acquiring another of these abandoned machines and overhauling it for service in a contemplated vapor recovery system for the plant.

Construction and installation of all compressor units at the plant have been somewhat retarded by manpower shortage, but completion is expected within the next month. Initial operation is expected to produce more than 100,000,000 cu. ft. of gas monthly for main line distribution. It is expected that field pressure decline and other factors may eventually require the compression of much of the gas-well gas in the area and the installation of facilities at the present time will undoubtedly conserve and prolong the producing life of the field so that the supply and demand of natural gas fuel for this area will be balanced for the present and possibly far into the postwar period.

☆ ☆ ☆

End view of the four 300-hp. 8-cylinder V-type compressors on foundation

TRY THIS CATALYTIC-CRACKING QUIZ

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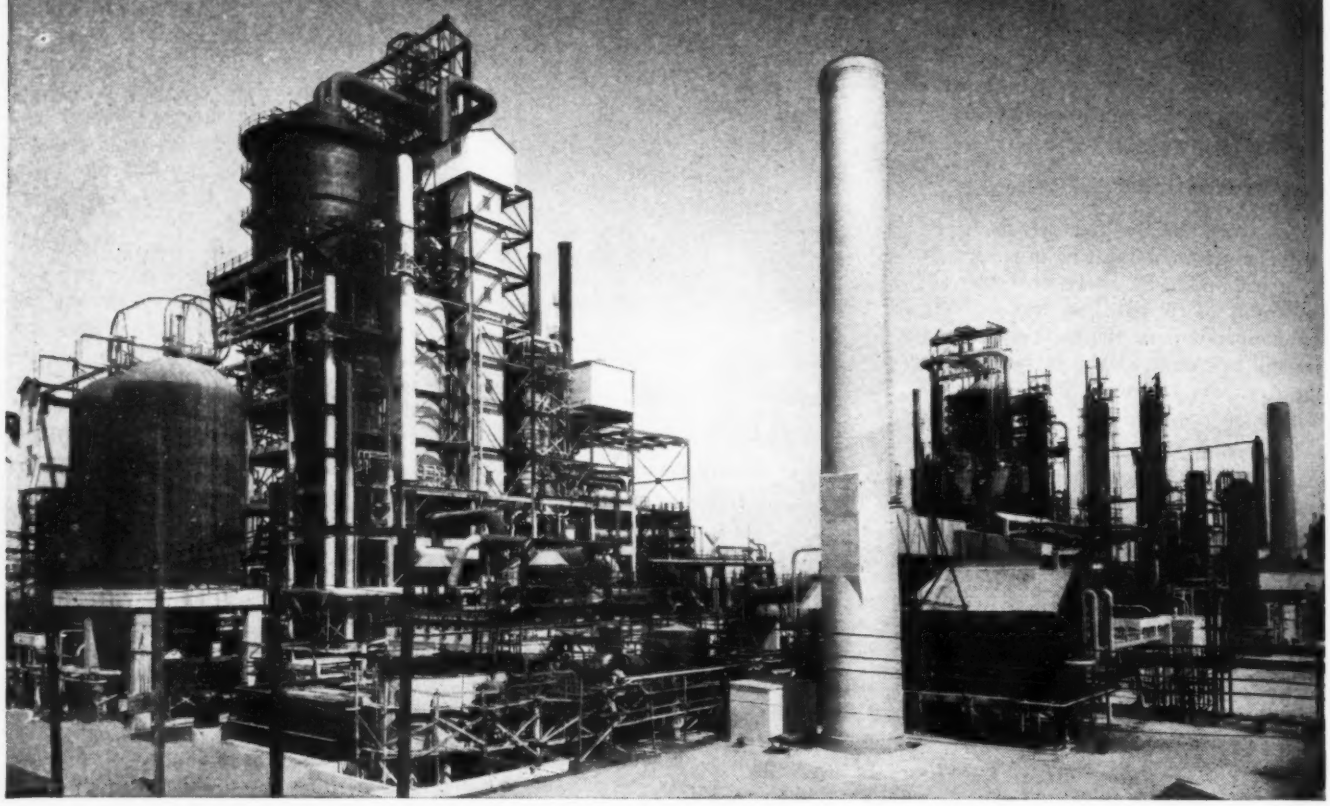

QUESTION 1: What process now leads in production of the nation's high-octane gasoline requirements?

ANSWER:

Current figures show that when *all* catalytic-cracking fresh feed capacity is considered – including pre-war fixed-bed catalyst processes – the *Fluid* "Cat-Cracking" process now comprises over 50% of the industry's capacity! Further, the ratio of *Fluid* "Cat-Cracking" capacity to that of the nearest competing process is over *two-to-one!*

QUESTION 2: Why are leading refiners sold on this process?

ANSWERS:

1. When built, *Fluid* "Cat-Cracking" plants operate as designed. Production meets specifications. War commitments are realized with efficiency to spare.

2. High efficiency is maintained under a wide variety of operating conditions. For instance, the severity of cracking effected by the ratio of catalyst to charge in the reactor can be varied as much as *twentyfold!* This unmatched flexibility characteristic of the *Fluid* "Cat-Cracking" process permits production today of the all-important high-octane and butadiene components from different types of feeds ... ranging from reduced crude to naphtha. Even high sulphur-bearing feed stocks can be proc-

essed by incorporation of a moderate amount of corrosion-resistant materials in the reactor. *Tomorrow*... this flexibility will permit use of the most economical of feeds to produce premium postwar products.

3. Control of product quality is simplicity itself. Due to the fluid properties of the catalyst... its flow responds to recognized principles. Operating conditions for any run can be quickly established and maintained with little, if any, adjustment of a few simple controls.

4. The flow principle of the catalyst system requires no moving mechanical parts, thus assuring a high service factor. On-stream runs of 4 to 6 months have been reported to date. In addition to this saving in operating time... conventional maintenance costs are reduced to a minimum.

Small additions of catalyst which are easily and regularly injected into the system maintain the catalyst at high efficiency. Manpower costs for operation and maintenance are also minimized.

QUESTION 3: What has M. W. Kellogg contributed to catalytic-cracking?

ANSWER:

On the record... *over two-thirds* of the *Fluid* "Cat-Cracking" capacity built since Pearl Harbor—and now in operation—has been built by The M. W. Kellogg Company. Our laboratory helped develop the *Fluid* technique ... our engineers translated it into commercial reality. Today, our continuous pilot-plant operation provides the accurate data necessary to evaluate feed stocks and to evolve process designs for specific applications.

CONCLUSION:

Based on its war record of production of high-octane and butadiene components... its proven advantages... its postwar future... the *Fluid* "Cat-Cracking" process is the overwhelming choice of leading refiners.

Based on its experience with the *Fluid* "Cat-Cracking" process from laboratory inception and pilot-plant operation through process design and construction... The M. W. Kellogg Company offers an unduplicated "know-how" to refiners planning future installations. Yet this is but one phase of M. W. Kellogg's Complete★ Service to refiners.

Whatever the problem in modernization of existing facilities, our approach to that problem must meet two aims: hasten victory ... provide our client with an "edge" in the forthcoming postwar competition.

The contents of this advertisement have been cleared with the War Department and the Office of Censorship.

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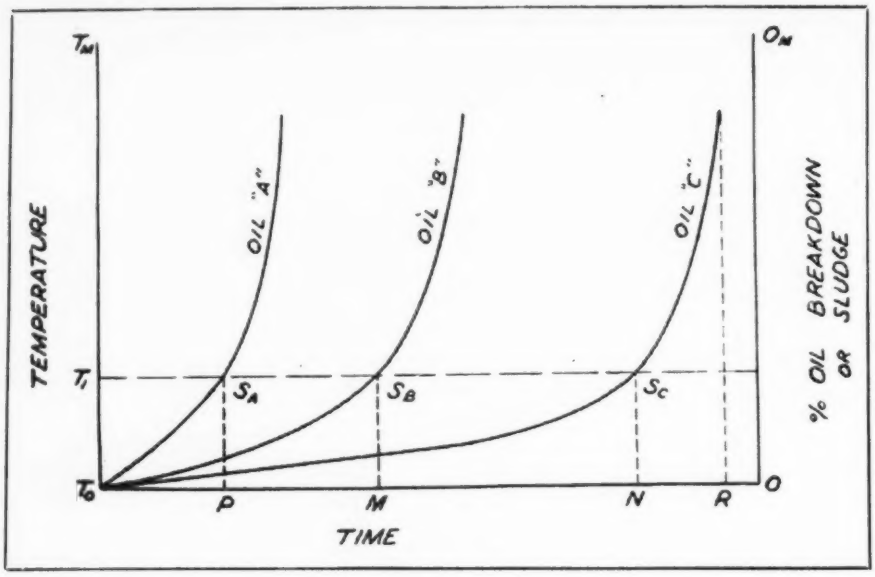

Fig. 1. Illustrating graphically the effect of temperature and time on the degree of oil breakdown

PETROLEUM ENGINEER Exclusive Feature

Heavy Duty Motor Oils for Internal-Combustion Engines

☆ Use of detergent-type additives and test procedures for their evaluation

by W. J. Backoff and N. D. Williams

Research and Development Laboratory, Pure Oil Company

THE use of addition agents in petroleum lubricants is obviously not a recent development, as the industry has for years made use of soaps and fatty acids in grease manufacture, animal and vegetable oils in steam cylinder and marine engine oil processing, as well as fatty oils together with such chemicals as sulphur, chlorine, and phosphorous in the manufacture of cutting oils. More recently additives containing such elements as sulphur, chlorine, phosphorous, and lead have been successfully used in differential and transmission lubricants. It was not, however, until the late 1930's that petroleum oils containing detergent type additives were commercially available for use as lubricants in internal-combustion engines.

Oils containing these detergent type additives have generally been referred to as heavy duty motor oils and actually they are just that. They allow satisfactory operation of both diesel and gasoline engines under higher speeds, higher temperatures, and higher loads than are possible with straight mineral oils of even the highest quality.

These more severe operating conditions exist almost entirely in truck and bus operations and, to a limited extent, in certain heavily loaded stationary engine installations. The passenger cars now available, and probably those available for some time after the war, will derive little, if any, benefit through the use of heavy duty crankcase oils as they are now known. The main reason for this is that the combinations of engine speeds, temperatures, and loads in passenger cars are not too severe and, therefore, well refined mineral oils can adequately lubricate these engines.

It has been mentioned that increases in speed and load were the main factors creating the need for heavy duty motor oils in truck and bus operations; consequently in the development of heavy duty motor oils, it is essential to know the effect these factors have on the lubricating oils.

Lubricating oil on prolonged exposure to engine temperatures absorbs oxygen from the air, trapped in the crankcase or surroundings, and undergoes oxidation. This chemical breakdown is evidenced by the formation of deleterious products, which may be broadly identified as: (1) organic acidity, (2) oil insoluble sludge, and (3) oil soluble sludge or "varnish."

The amount and rate of formation of

W. J. BACKOFF received B.S. in chemical engineering from University of Illinois in 1934—With Pure Oil Company since 1934 as tester, junior engineer, research engineer—Last year in charge of automotive laboratory division of Pure Oil research and development laboratory.

N. D. WILLIAMS was graduated from University of Chicago in 1931 with B.S. in chemistry—With Pure Oil Company since 1932, serving as analytical control chemist and research chemist—In charge of product development work for automotive laboratory division last year.

Both writers have spent several years in development of additives for gasoline, motor oils, and extreme pressure lubricants in addition to development of mechanical tests and test procedures for the evaluation of these additives.

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FIG. 158 GLOBE

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FIG. 160 BALL CHECK VALVE

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Corresponding ball check valves, Fig. 160, with same ratings, also available.

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Globe type, screwed or socket welding ends

SIZE	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"
End to End, Fig. 158 and 160	3¾	3¾	3¾	4½	5⅛	6½	7½	9
Center to Top Open, Fig. 158	8¼	8¼	8¼	9¼	10⅞	13¾	14⅞	18
Handwheel Diameter, Fig. 158	5⅜	5⅜	5⅜	6⅜	8½	10⅛	10⅛	11½
Weight—lbs, Fig. 158	3¼	3¼	4¾	7	12	22	37	62
Weight—lbs, Fig. 160	1½	1½	2¾	4½	7¼	13½	19¾	40

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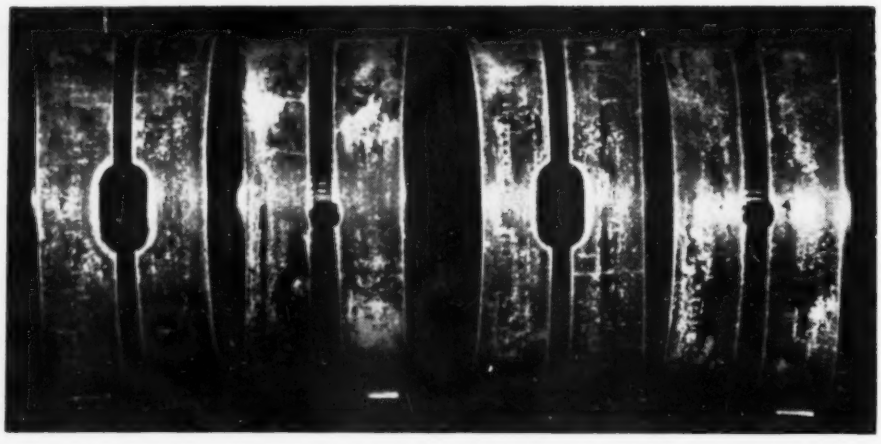


Fig. 2. Copper-lead type of bearings corroded from excessive acidity

the products of oxidation depend on the type of oil used, the method and degree of refining, and the length of time that a lubricant has been exposed to engine temperatures. Fig. 1 graphically illustrates the broad aspects of the effect of time on the degree of oxidation for three oils of varying stability.

Oil "A" would be classified as a very unstable lubricant of little or no oxidation resistance. It would deteriorate rapidly with increased temperature. Oil "B" is a moderately stable lubricant over the temperature range T_o to T_1. Above temperature T_1 or after time T_oM the lubricant begins to oxidize at a moderately fast rate as evidenced by the rather sharp change in slope of curve B above point S_B. Oil "C" is a very stable lubricant over an extended period of time T_oN. After extended use, however, as represented by T_oN, or if subjected to temperatures above T_1, rapid deterioration occurs over the short increment of time as represented by NR.

The relative amount of oil breakdown, or the time required for a given amount of breakdown, for each oil at any time may be represented by extending a horizontal line from any point or curve on A, B, or C to the ordinate $O\ O_M$. The vertical distance of the intersection of this horizontal line with ordinate $O\ O_M$ is therefore a measure of the degree of oxidation for a given time and/or temperature.

In order to understand further the nature of oil oxidation, it is perhaps logical to discuss each type of oxidation product mentioned above and its effect on both advanced oil oxidation and engine performance.

Organic Acidity

The organic acids produced by oil oxidation are, of course, considered extremely weak acids. In the presence of traces of moisture, however, small amounts of these acids, particularly the lower-molecular weight volatile acids, are quite corrosive to the bimetallic bearing metals of copper-lead, silver-cadmium, etc. Examples are illustrated in Fig. 2. In the absence of moisture most oils will tolerate a higher degree of acid formation before the problem of bearing corrosion becomes serious. The presence of acidity in a lubricating oil, however, increases or catalyzes the rate of formation of greater and more critical amounts of acidity and attendant sludge and varnish.

Oil Insoluble Sludge

The upper part of the piston of an internal-combustion engine is exposed to near combustion temperatures and resulting hot gaseous products of fuel combustion, presenting the severest temperatures to which a lubricant is exposed. The attendant upper piston temperatures are near or above the actual thermal decomposition temperatures of most lubricants. Any portion of the lubricant exposed to these temperatures will carbonize and leave as a residue a carbonaceous thermally-decomposed portion of the lubricant shown in Fig. 3.

This carbonaceaus material is composed of actual carbon and a "gummy" highly polymerized binder, which is deposited back of the piston rings and in time prevents proper ring action; promotes loss of power, and causes ultimate ring sticking. A portion of these carbonaceous deposits, although oil insoluble, are mechanically carried into the main body of crankcase oil and, by a settling out process, become the source or reason back of clogged oil filters, faulty valve action, or impaired overall engine efficiency. For practical purposes, this carbonaceous material is looked up-

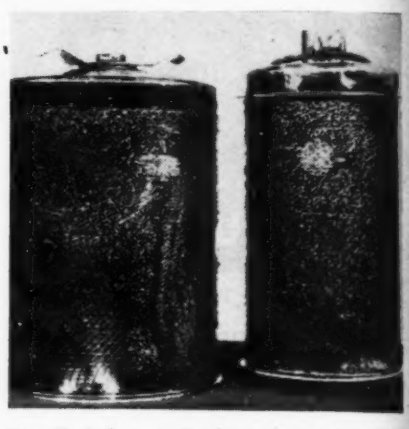


Fig. 3. (Above) Carbon deposit resulting from lubricant being exposed to severe temperatures

Fig. 4. (Below) Use of an oil saturated with varnish often results in a deposit of kind shown here

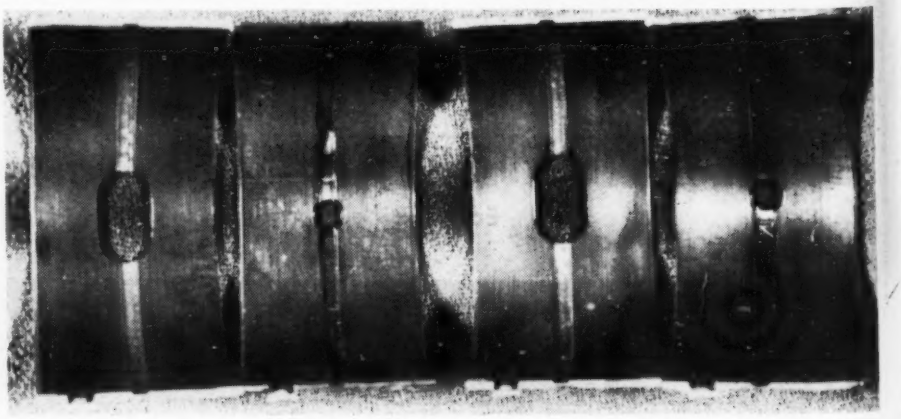
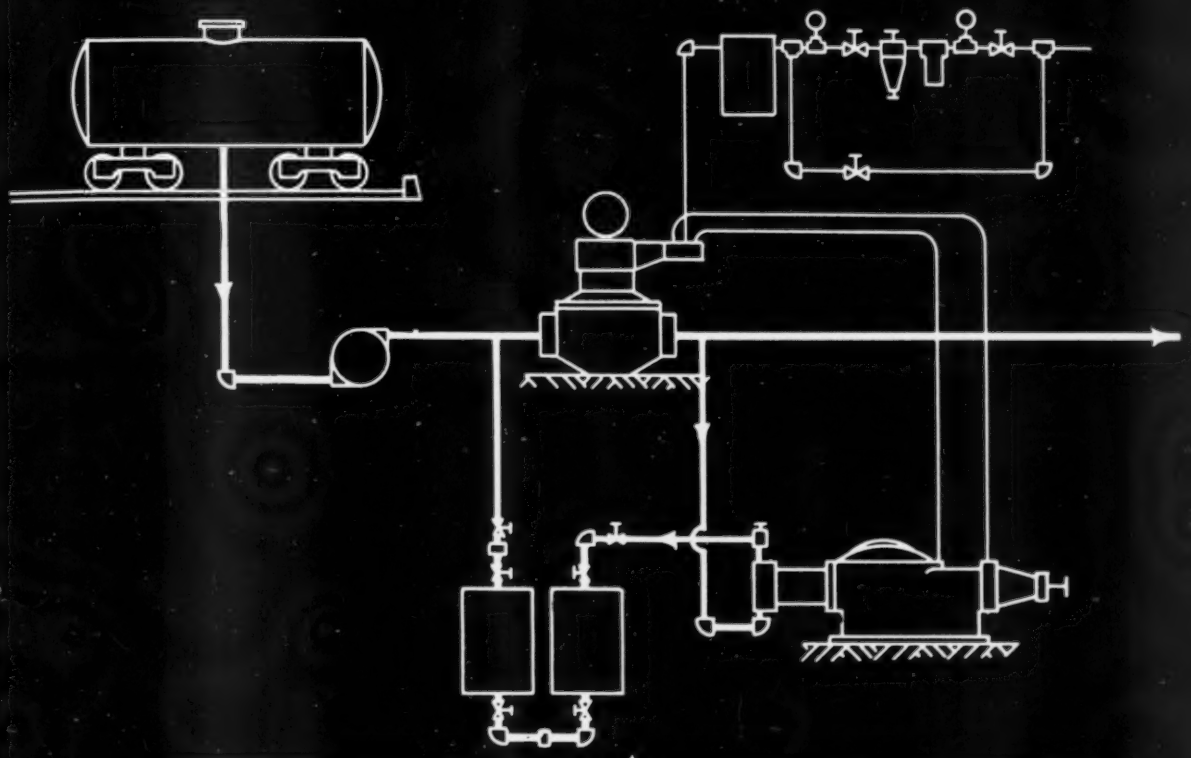


Fig. 5. Protective film deposited on these bearings arrested acid corrosion. Note darkened bearing surface. Compare this picture with Fig. 2

SAMPLING



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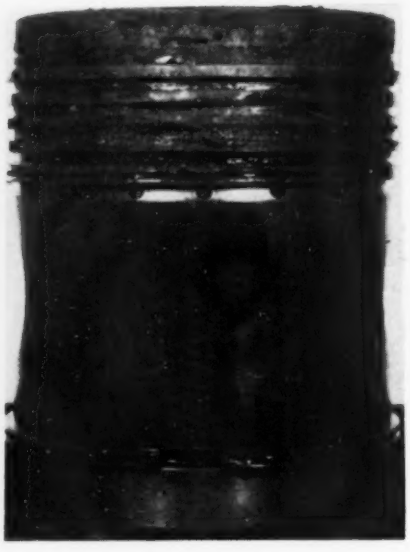


Figs. 6a (left) and 6b (right). Pistons from heavy duty diesel lubricating oil test showing cleansing effect of detergent type additive on lubricant. Fig. 6a shows results of not using additive and Fig. 6b the results when it is used

on as the final or highest state of oil deterioration.

Oil Soluble Sludge

Oil soluble contamination products, or varnish, as the name implies, are comparable in color and appearance to the more commonly known floor varnish. This oil soluble form of contamination is produced under less severe temperature conditions than the insoluble form of sludge and is therefore classified as an intermediate stage of oil oxidation.

Oil soluble varnish formation is associated with the temperature range of the piston skirt and, on forming, is retained in solution or dissolved by the main body of the crankcase lubricant. The solvent action of the lubricant for its soluble varnish continues until saturation, after which deposition occurs.

Oils of the naphthenic or aromatic type have been shown to possess higher solvency for these decomposition products than paraffin type oils. Innumerable engine tests have, however, shown that over a given temperature of operation the rate of oxidation is greater for the high solvency oils and as a result such oils may reach their saturation point, as regards soluble sludge content, long before the more paraffinic oils show more than traces of oxidation.

Prolonged use of an oil saturated with varnish may often result in abnormal deposition of this type oxidation product on the lower part of piston, cylinders, and crankcase (Fig. 4). It is obvious of course that a lubricant approaching the saturation point as regards soluble sludge will be more susceptable to abnormal carbonaceous decomposition in the regions of higher engine temperatures.

Lubricants high in varnish content are characterized by high increase in viscosity and often attain a critical value beyond which the oil pump and lines cannot handle them. Engine parts are thus deprived of adequate lubrication and mechanical failures such as burned out bearings, scored cylinders, and the like may soon follow.

Antioxidants

Petroleum refiners have developed many processes and methods aimed at removing certain of the inherent components of an oil that are easily oxidized and responsible for the sludge-forming tendencies attributed to the main body of the lubricant. Lubricants have resulted that are designed to contain a

Fig. 7 (left and lower left). Piston and valve cover plate from engine lubricated with a well refined oil containing a "metal passifier" type inhibitor

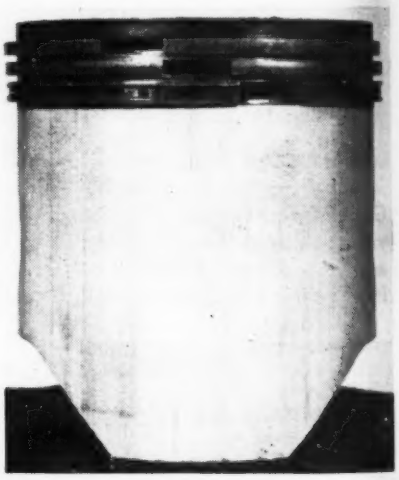
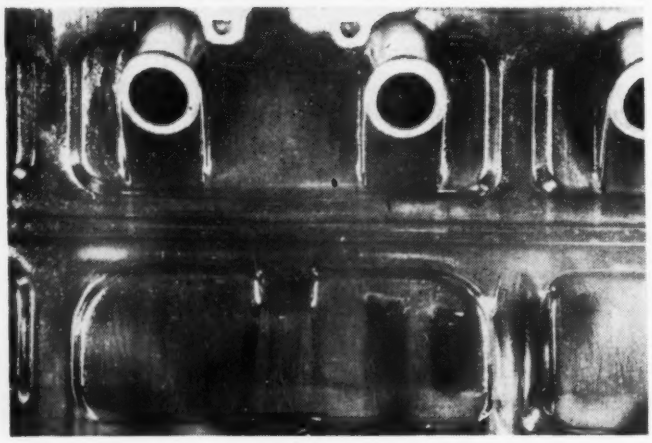
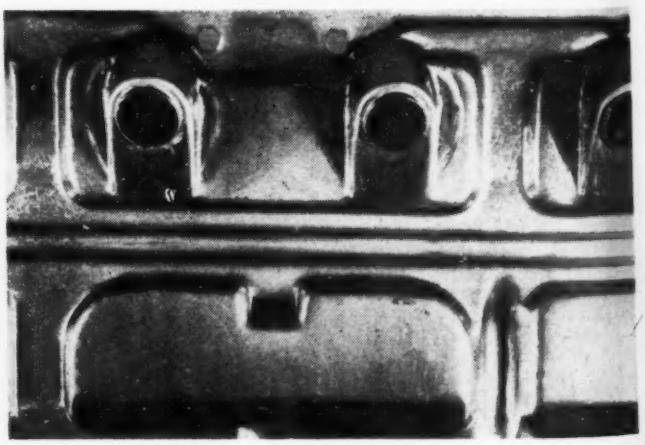


Fig. 8 (right and lower right). Piston and valve cover plate from engine lubricated with same type oil as Fig. 7 reinforced with a detergent inhibitor type additive. Note bright metal surfaces of the piston and lack of sludge (dispersive action) on valve cover plate





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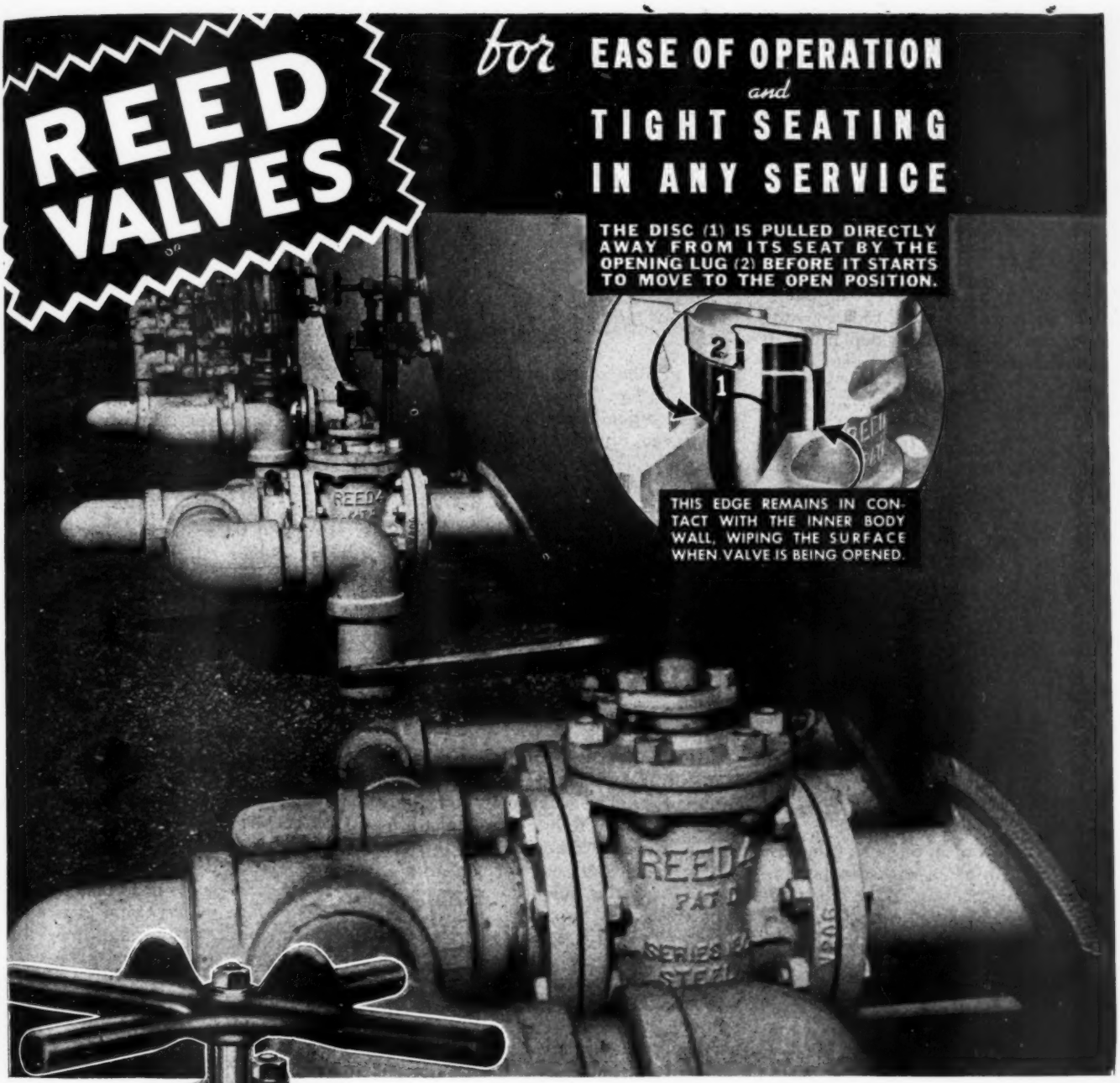

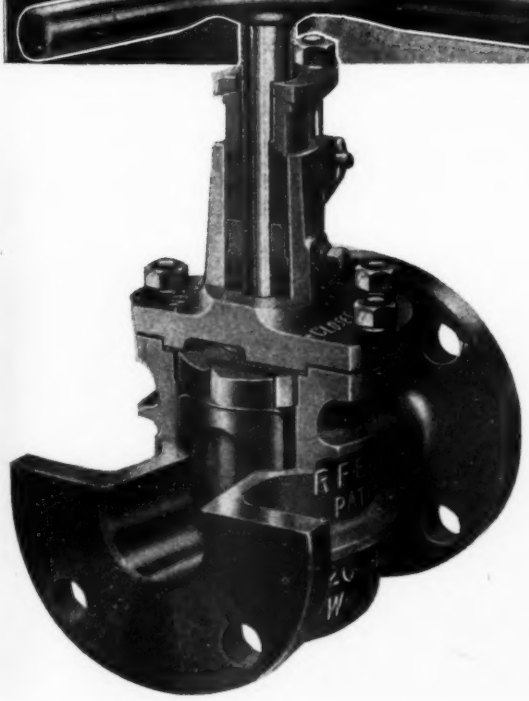

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minimum amount of deleterious components and still retain the maximum required amounts of stable or inherent antioxidant components that promote overall lubricant base oil stability.

Research studies have led to the isolation of the natural antioxidant components of lubricating oils. Such studies have enabled the petroleum chemist to prepare synthetically chemical additives that are chemically similar or compatible with the naturally occurring inhibitors and are often added to heavy duty lubricants in amounts demanded of present day engine severity. These chemical reinforcing agents or antioxidants fulfill either one or both of the following purposes:

1. **Arrest or suppress the natural ability of the lubricant to absorb oxygen.**
2. **Poison or deactivate hot metal surfaces of engine parts and thus render them inactive as catalysts to lubricant oxidation.**

The compounds of sulphur and phosphorous, most common of the metallic deactivators, have a high affinity for hot metallic surfaces and form very thin coatings of sulphides or phosphides on exposed metal surfaces. (Fig. 5). Many compounds of sulphur and phosphorous also possess true antioxidant characteristics although nitrogen-containing materials are more often associated with the true antioxidant additives.

Detergency

Proper refinement of lubricating base oil stocks reinforced with suitable oxidation inhibitors have done much toward the promotion of better operating engines. Certain natural-occurring engine processes and lubricant characteristics still exist, however, and often overburden even the most stable of lubricants. Most common are:

1. **The natural tendency of the lubricant to absorb the excess oxygen present in the blowby gases.**
2. **High ring belt temperatures that are characteristic of the newer high output engines, and are often above the thermal decomposition temperature of the lubricating composition.**
3. **The contaminating influences of unburned fuel residues (soot) that find their way past piston rings into the main body of lubricating oil.**

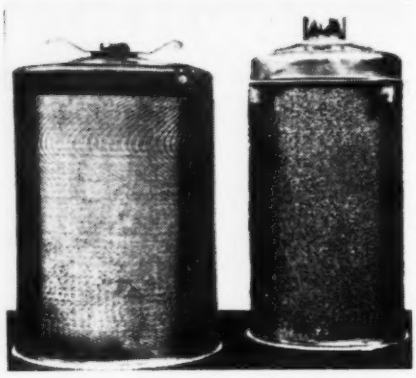


Fig. 9. Comparison of these filters with those in Fig. 3 again shows ability of the detergent-dispersion type agent to prevent abnormal engine deposits

The above conditions are expected and must be tolerated; hence, means have been devised whereby the products of natural or limited decomposition can be prevented from impairing engine operation. Toward this end the detergent type additive has found its use.

The detergent type of chemical reinforcing agents are usually metallo-organic salts. The metals most commonly used are zinc, tin, nickel, calcium, lithium, barium, aluminum, and potassium. The acidic organic radical most often contains sulphur and/or phosphorous, which promote mineral oil solubility of the additive salt, as well as provide the antioxidant-metal passifying characteristics described under "Antioxidants." The detergent type additives should, however, basically provide: (a) Prevention by cleansing (soap) action of newly formed oxidation products from adhering to the engine parts at the time of formation or, in some cases, removal of previously formed deposits. (b) Sludge dispersion or prevention of any contaminant described under (a) from physically separating from the main body of crankcase lubricant and later depositing throughout the engine.

The cleansing action of a detergent type additive is well illustrated in Figs. 6a and 6b. Note in particular the heavy carbonaceous deposits adhering to the top lands and rings of the piston and the extremely dirty condition of the lower piston skirt of the piston shown in Fig. 6a. The piston in Fig. 6b was obtained by using the same oil that had been reinforced with a small amount of metal salt.

The engine parts shown in Figs. 7, 8, and 9, are also typical examples of both combined detergency-dispersive action of a preferred heavy duty lubricant. The lubricant that produced the condition shown in Fig. 7 was a well refined base oil, high in antioxidant characteristics. The severity of engine operation was such, however, that it produced the conditions shown. Reinforcement of this same lubricant with a detergent-inhibitor combination not only provided increased cleansing action shown in Fig. 8, but further improved engine cleanliness by keeping the sludge thoroughly dispersed throughout the oil. Decrease in overall engine dirt is further evidenced by the clean conditions of the filters shown in Fig. 9.

Having described the effects and, to some extent, the remedial steps necessary to more or less neutralize these effects of high speeds, temperatures, and loads on lubricating oils, it is found that a good heavy duty motor oil, in addition to the normal properties of well refined mineral oils, must, in summary, possess the following properties: Oxidation resistance, detergency, dispersion, and corrosion resistance.

The testing equipment generally used for the evalution of these properties can be classified in three categories: The

Fig. 10. Single cylinder engines used to evaluate varnish and bearing-corrosion tendencies of heavy duty motor oil

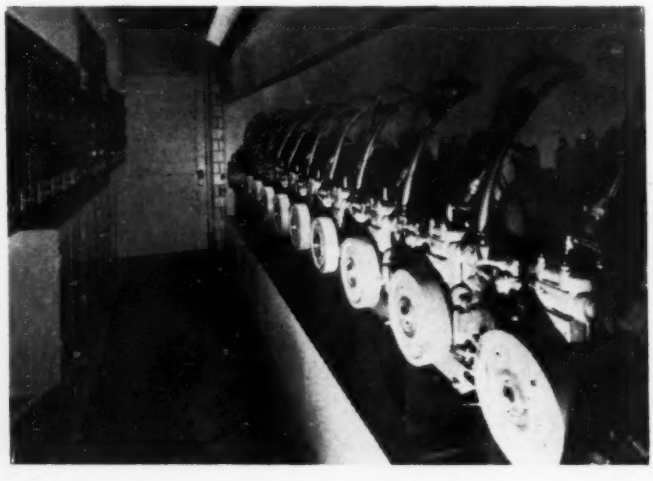
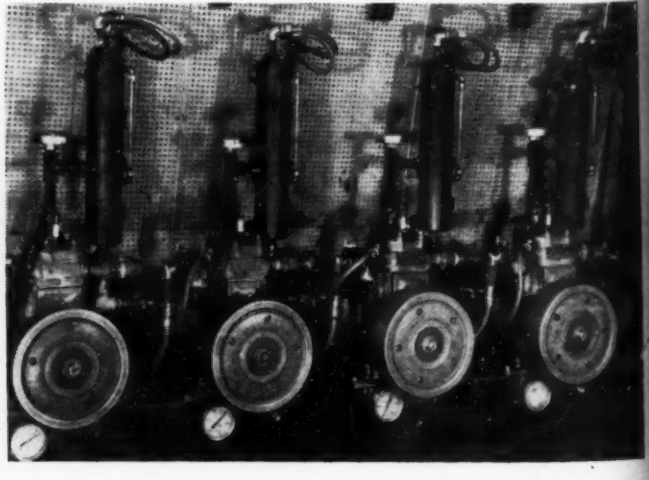


Fig. 11. Single cylinder engines used to evaluate ring sticking tendency of heavy duty motor oil



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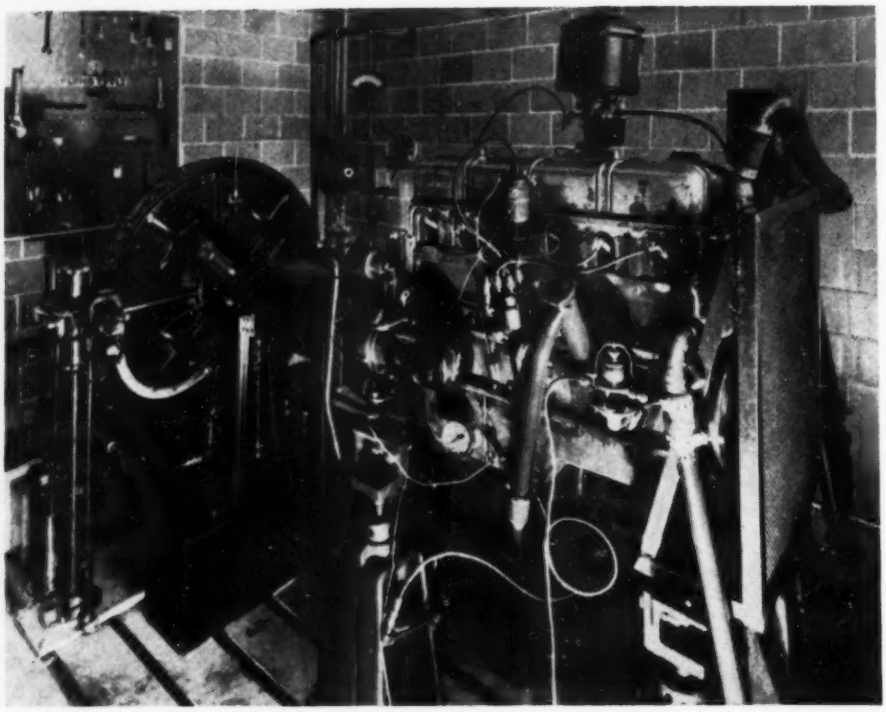


Fig. 12. Full scale gasoline engine used to evaluate varnish and bearing-corrosion tendencies of motor oil

test tube, the bench test, and the full scale engine.

The test tube varieties usually consist of glass-constructed apparatus used to measure oxidation resistance at temperatures up to 400° F., or mechanical devices designed to evaluate corrosion tendencies of the oils. These tests have been very useful as primary or screen tests, as many lubricants can be tested in a reasonably short time at low cost.

The bench test type of equipment, normally used in the secondary evaluation of heavy duty motor oils, consists of small one cylinder engines. By varying operating conditions of these specially built engines, all essential performance properties of oils may be measured, but here again, as in the primary test tube tests, it is a screen test although the mesh is considerably finer.

At least two different operating procedures are usually set up on the small single cylinder engines, one procedure to measure the varnish or lacquer forming and the bearing corroding tendencies of the oil and the other procedure to measure the ring sticking properties. Fig. 10 shows a typical bench test stand of engines being used to evaluate the varnish forming and bearing corrosion characteristics of the oil. These engines are run at normal cooling jacket temperatures and high crankcase temperatures (300° F.). The group of engines shown in Fig. 11 are set up to operate under ring sticking conditions and here abnormally high cooling jacket temper-

Fig. 13. Diesel engine used for ring sticking tests

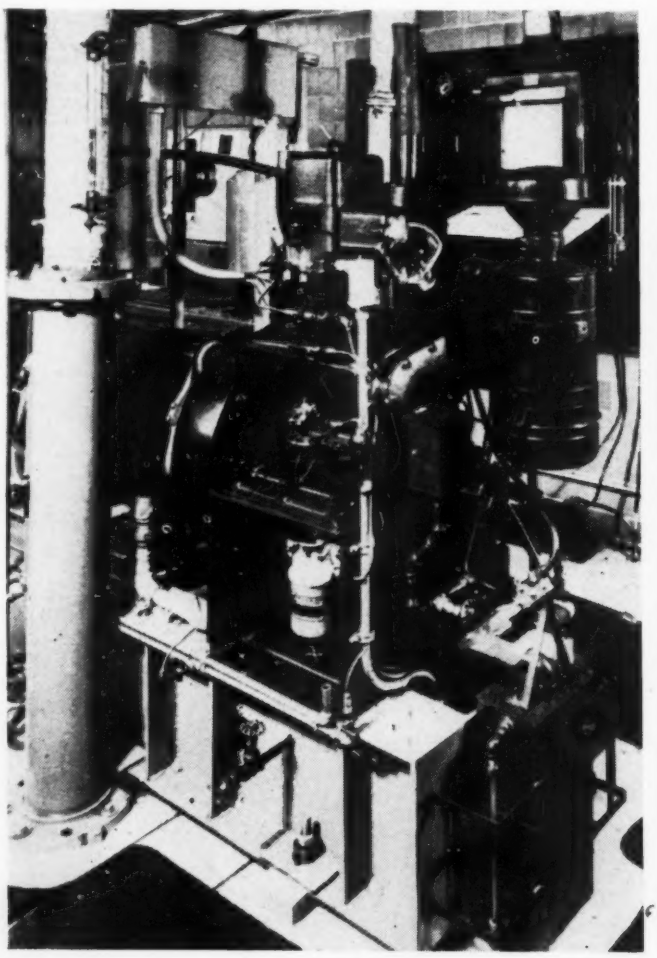
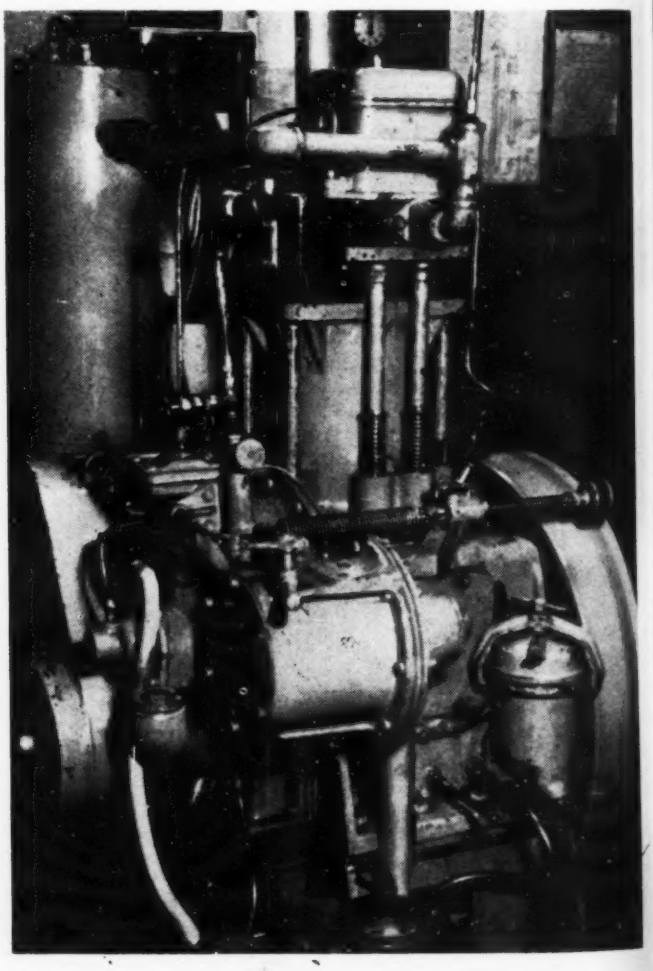
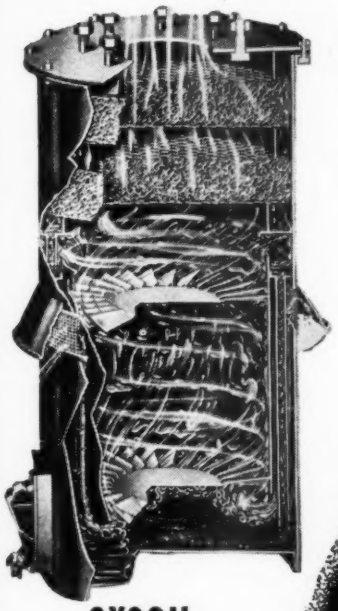


Fig. 14. Diesel engine used for film strength and endurance tests





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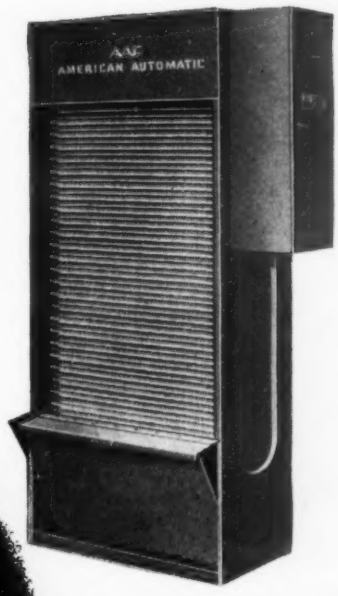

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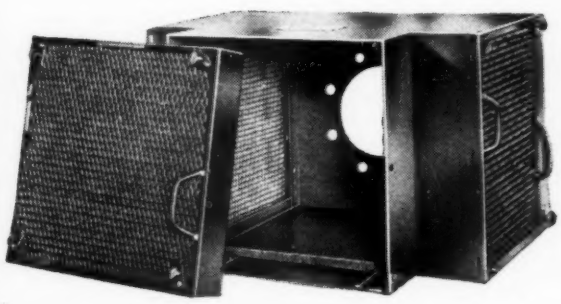

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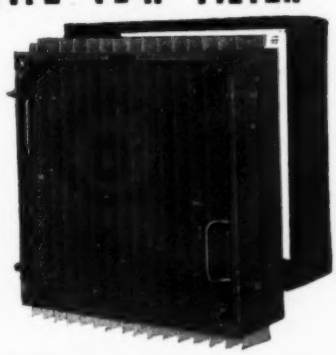

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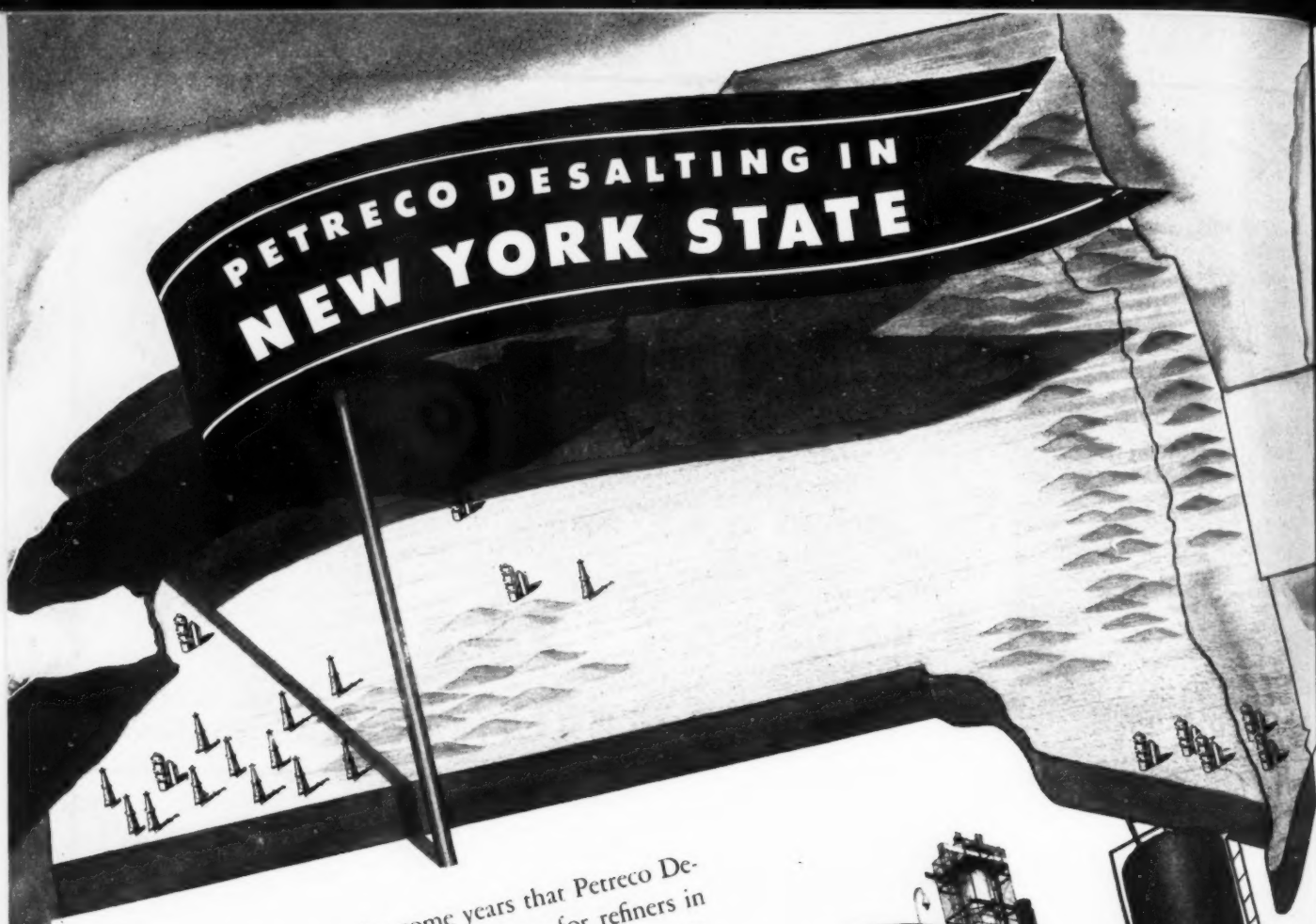

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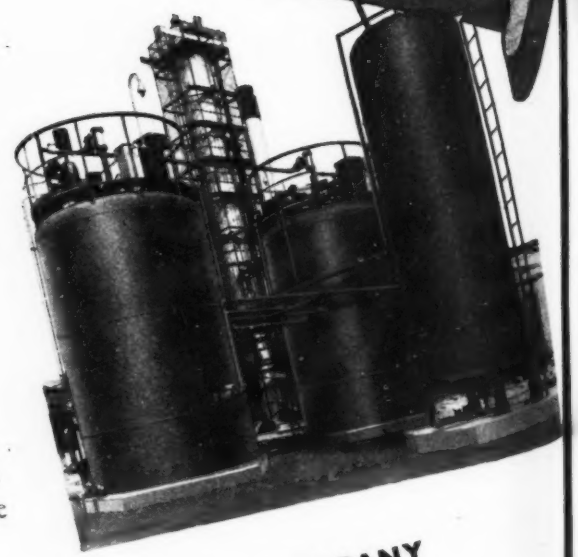

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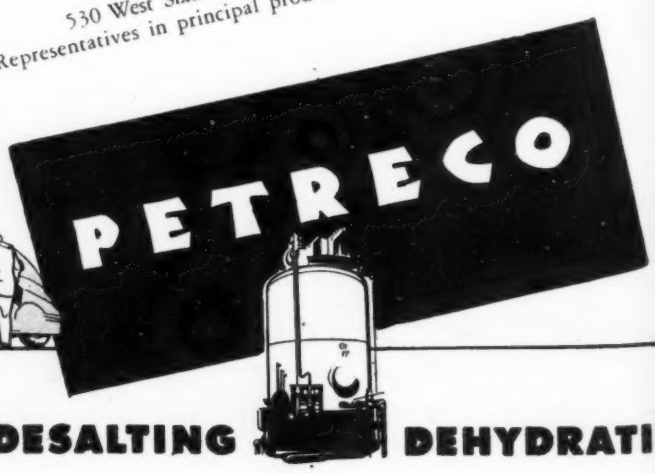

DESALTING DEHYDRATING

atures (400° F.) and moderate crankcase temperatures (225°F.) are used. In this test the detergency properties of an oil become apparent.

After a lubricant has given indication of possessing all essential properties desired by passing these tests it is ready for full scale engine tests. Because they represent the most universally used types of engines and because they afford varying oil-operating temperatures and loading conditions, the full scale engines are of two general types, the gasoline or automotive type engine and the diesel engine. The gasoline powered engine shown in Fig. 12 is used for a final laboratory evaluation of the oxidation and bearing-corrosion characteristics of heavy duty motor oil for gasoline engines. The test is run for periods of 36, 72, or 108 hr. at a speed equivalent to approximately 60 m.p.h. under road load conditions. The cooling jacket temperature is maintained at 200° F. and the crankcase oil at 280° F.

Diesel Test Engines

Shown in Figs. 13 and 14 are two different diesel engines of the industrial type in which the heavy duty motor oils undergo further tests. The engine in Fig. 13 is used to determine the ring sticking tendency of the oil under abnormally high jacket temperatures (240° F.).

The engine shown in Fig 14 is used under two different sets of conditions. In one test the engine is run under moderately high temperatures and with one-half of the piston crown cut away to allow the hot combustion gases to play directly on to the upper ring belt (Fig. 15). This test of 3-hr. duration measures the ability of the oil to maintain a lubricating film under the most adverse condition.

The same engine with a standard piston (Fig. 16) is used for an endurance test of 48-hr. duration. The engine is run under moderately high crankcase and jacket temperatures and high overload and is used to measure detergency, dispersion, and oxidation properties of heavy duty motor oils for diesel uses. Several other types of both full scale diesel and gasoline powered engines are also used to measure these same properties of heavy duty motor oils under varying operating conditions.

In all cases the full scale engine tests are designed to run under conditions that enable the investigators to predict field performance without running excessively long time tests. For these reasons accelerated conditions and varied types of engines are used.

It is sincerely hoped that as heavy duty motor oils are improved, the engine testing technique in the laboratory will also improve so that more than two full scale engines will be needed accurately to predict field performance for heavy duty motor oils. At the present state of knowledge of heavy duty motor oils and their use, however, no one engine or set of operating conditions will give the accurate prediction necessary. It is only after carefully evaluating and analyzing the results of these varied engine tests that satisfactory field performance is assured.

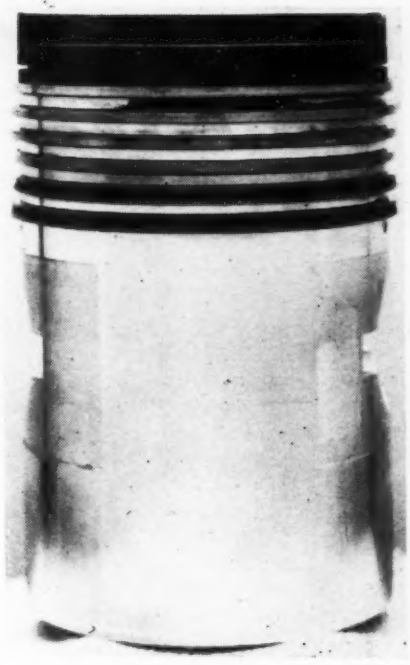

Fig. 15. Piston of the type used in measuring film strength characteristics of heavy duty motor oil

Fig. 16. Piston from diesel engine used in endurance test

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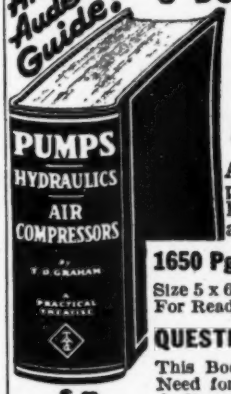

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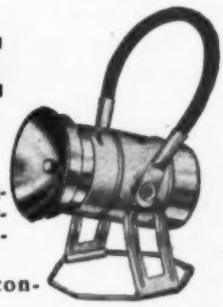

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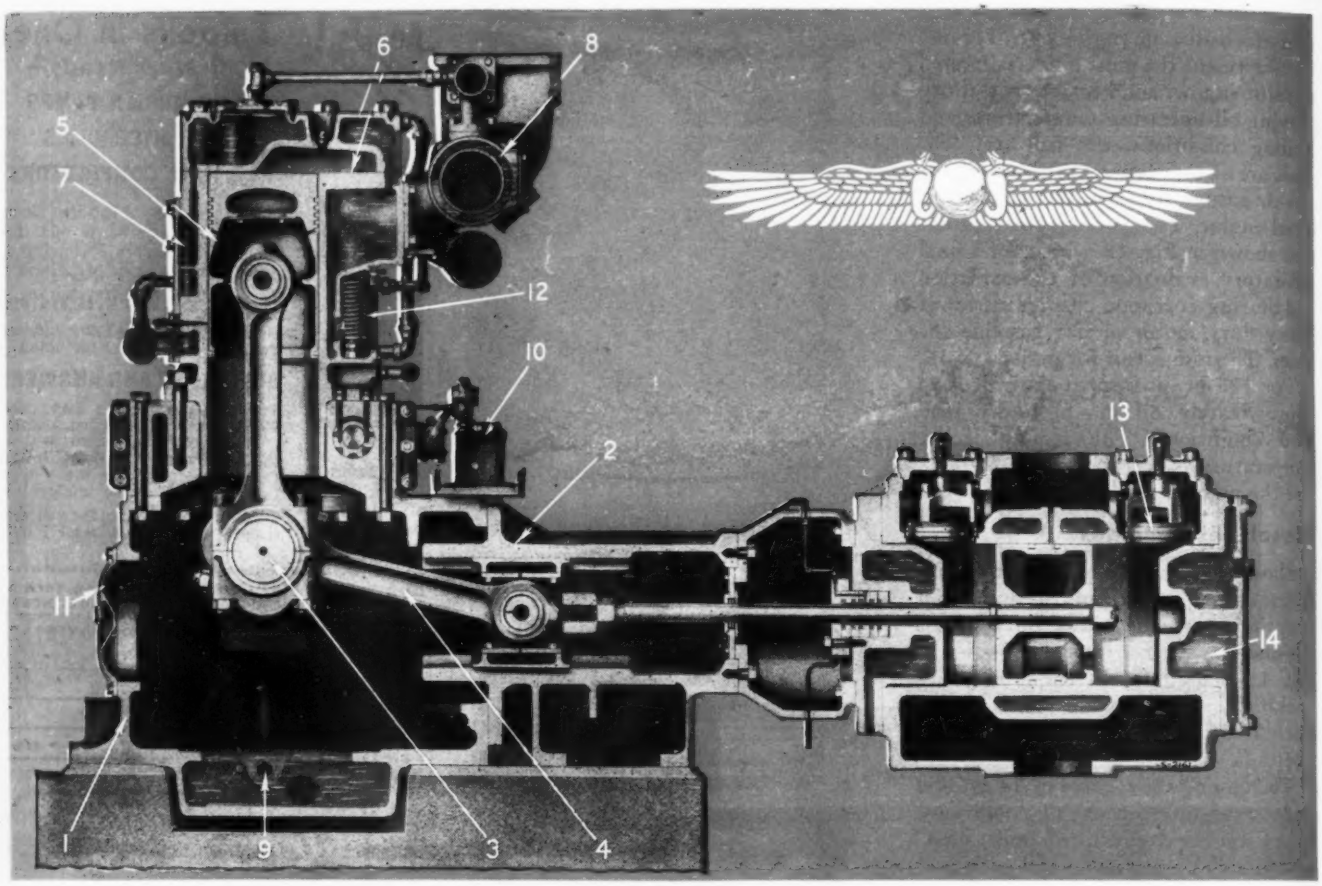

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Switchgear for Electric Power Distribution In Process Areas

☆ Switchgear is evolving in specialized forms most suitable to refinery service

by Merritt A. Hyde

Westinghouse Electric and Manufacturing Company

SWITCHGEAR for refinery power distribution performs an unspectacular but exacting job. As long as process units are on stream, electric power must be delivered to them with the highest degree of continuity. To carry out this vital task switchgear must possess all the usual qualifications for handling any high-load factor industrial service. In addition it must perform with sustained reliability under the conditions of corrosion that pervade the process areas; and it must do its job safely under such hazardous atmospheric conditions as may exist at the location. Although ordinarily it is feasible to install switchgear outside those areas where hazardous conditions are continuous, it is often necessary to make installations at points where the atmosphere is subject to hazard at times.

To meet these conditions, switchgear for use in process areas is evolving in specialized forms, just as motors and motor starters have developed in types particularly suitable to refinery service.

Lighting Distribution

Consider first the protection and control of lighting distribution circuits. The switchgear apparatus required for this job is physically small but important in function. Many refineries have found the oil-immersed lighting panelboard to be an effective solution to both the corrosion problem and the hazard of petroleum-laden atmosphere. Individual circuit breakers in sizes 50 amp. and below are assembled in an enclosure as shown in Fig. 1.

Oil submergence of the breaker units provides protection against hazardous atmosphere conditions and at the same time the oil prevents exposure of the active parts to corrosive elements. Fuses are eliminated and all the usual advantages of circuit breaker protection are gained. Weatherproof construction permits the most convenient location regardless of exposure. In view of the varied locations in which lighting panelboards may be installed, the breaker units for this service are compensated for variations in oil temperature, making their tripping characteristics practically independent of changes in ambient temperatures over a wide range.

Low Voltage Distribution

For the majority of circuits 600 v. and below, where maximum normal currents do not exceed 600 amp. and interrupting ratings of 10,000 amp. suffice, the provision of installations suitable for hazardous and corrosive conditions is relatively simple. In these ratings circuit breakers are readily available in individual housings either explosion proof or oil-immersed. Group mountings of such units can be made to serve effectively as low-voltage power distribution centers. These may be mounted indoor or outdoor, as convenient to the layout. Outdoor distribution centers in areas that are definitely nonhazardous may be made up using weath-

Fig. 1. Three 12-circuit oil-immersed panelboards provide reliable control and protection of lighting circuits in a modern refinery. Circuit breakers, submerged in oil, are isolated from corrosive and hazardous atmospheres

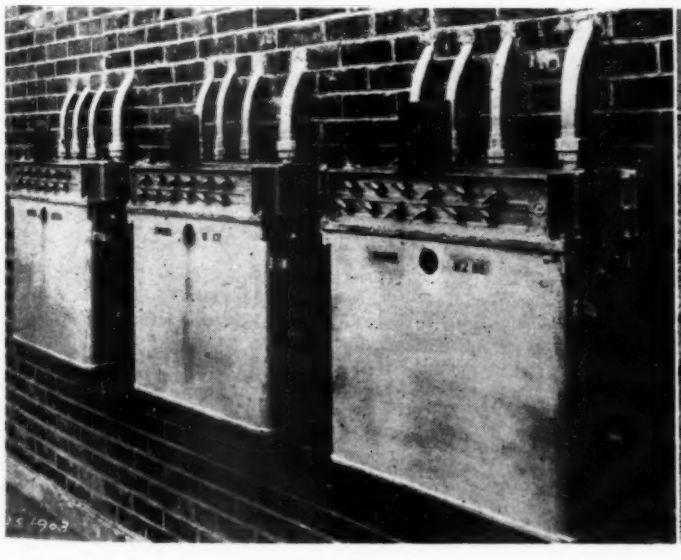
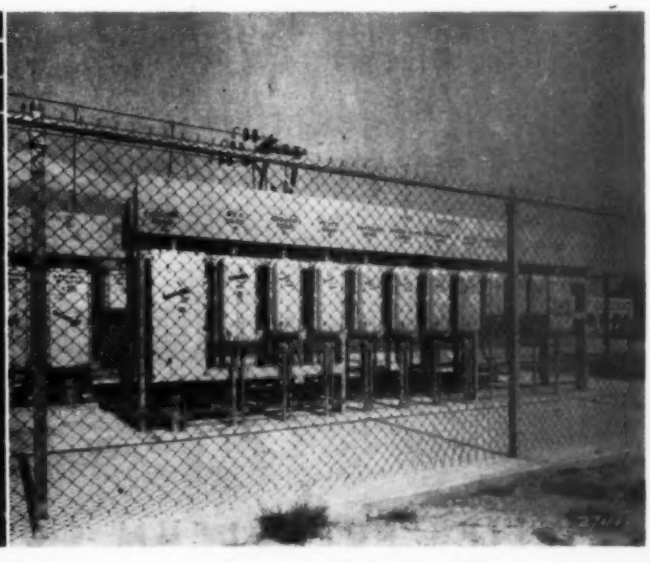


Fig. 2. This 440-v. power distribution center is made up of air circuit breakers in individual housings. Outdoor construction provides convenient layout at minimum installation expense



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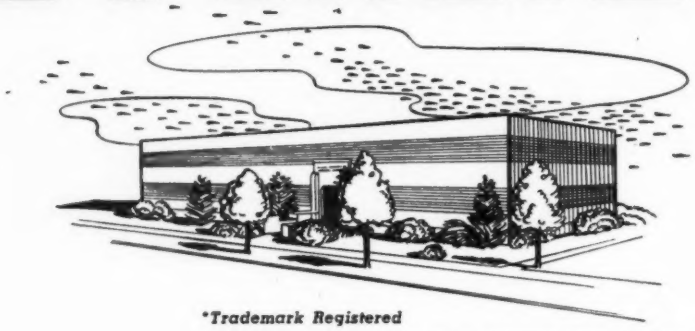

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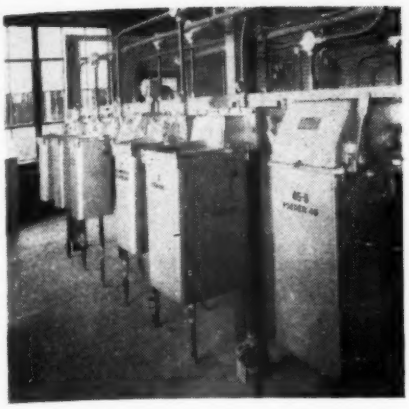


Fig. 3. Oil-immersed breakers, 600-v., control circuits to groups of motor starters in hazardous-atmosphere installation

Fig. 4. Installation of conventional switchgear in isolated room that is maintained non-hazardous by ventilation

er proof breakers; in such case, precautions should be taken to seal off effectively any conduits leading from the breakers into hazardous areas.

Fig. 2 shows a typical outdoor distribution center for 440-v. power in a refinery, using air type circuit breakers and combination motor starters. Fig. 3 is an installation using oil-immersed 600-v. circuit breakers to serve groups of oil-immersed motor starters. Breakers of this type in 100, 225, and 600-amp. frame sizes have for each size a number of interchangeable trip units to suit individual circuit requirements. This feature is advantageous where changes are required in circuit capacity, as well as in the maintenance of spares for operating contingencies.

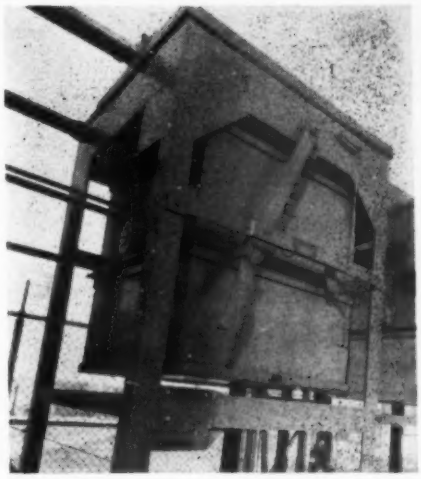
In the explosion proof air-break form, these breakers are available with combined thermal and magnetic trip, providing inverse-time-limit tripping at moderate overloads and instantaneous tripping on short circuit. In the oil-immersed form the breakers have magnetic trip only, providing instantaneous tripping on short circuit currents.

Where the installation requires circuit breakers in ratings exceeding 600 amp. on low voltage circuits or where distribution is at 2300 v. or higher, the physical size of the breaker unit makes it more difficult to provide an enclosure adequate for protection against corrosive and hazardous atmospheric conditions. Switchgear of these higher capacities is usually of the oil circuit breaker type.

High Voltage Distribution

Switchgear employing oil circuit breakers is frequently installed in specially built rooms isolated as completely as possible from the process area. Fig. 4 shows such an installation serving a large cracking unit. In some instances fan ventilation is used, drawing air from a point outside the area pervaded by the objectionable atmosphere. This arrangement is most effective when a slight pressure is maintained in the switchgear room, to insure that any seepage will be outward from the room rather than inward from the surrounding area.

Fig. 5. These outdoor-type completely oil-immersed units control 2300-v. power circuits in a refinery

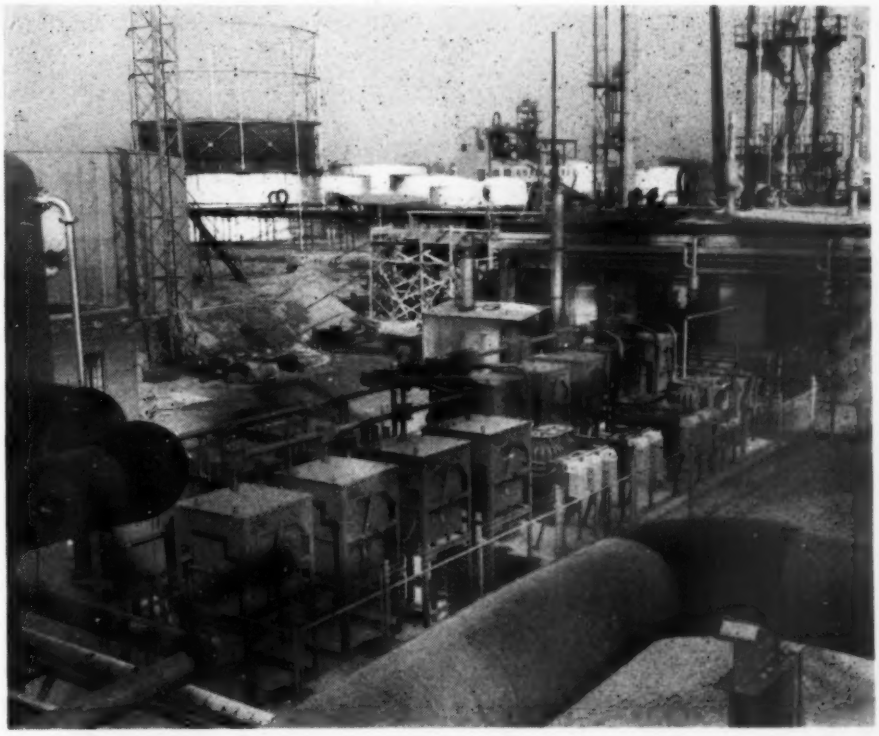


This practice is expensive from the installation standpoint, requires critical dependence upon the functioning of the ventilating system, and, even though extreme measures are taken to secure safe air at the intake of the ventilating system, there is usually some question on this point under variations in process operations and wind conditions.

The highest degree of protection against unfavorable atmosphere conditions has been attained in installations using switchgear units of the completely oil-immersed type. Such an installation is partly shown in Fig. 5. Each unit comprises an electrically operated circuit breaker and a disconnecting switch,

(Continued on Page 156)

Fig. 6. Switchgear units, 2300-v., of the completely oil-immersed type, 2300-v. oil-immersed motor starters, 2300/460-v. transformers and 460-v. oil-immersed circuit breakers form an outdoor power distribution and control substation in a hazardous area



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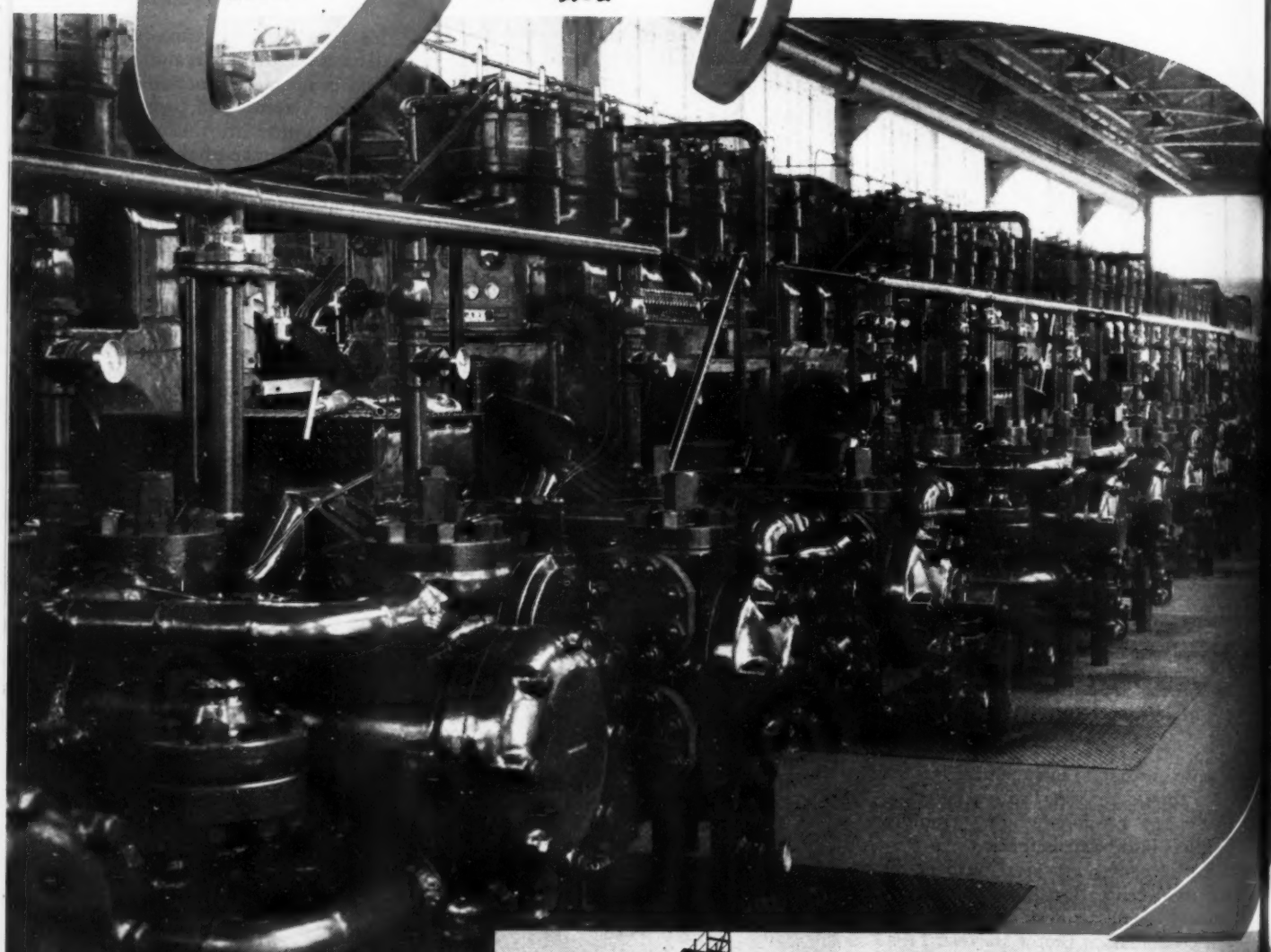

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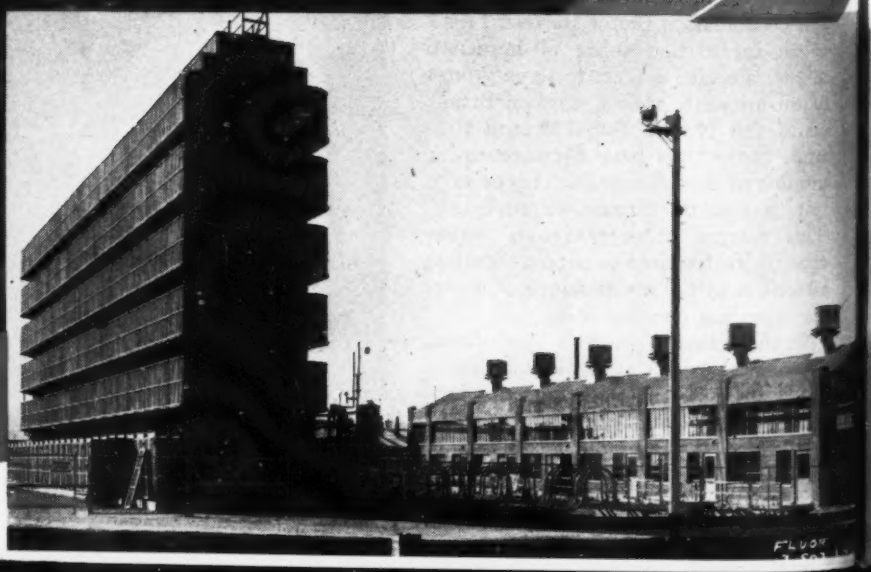

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2 CLARK 3000 H. P. steam-driven "Angles" in California refinery making Hi-Octane Gasoline

CLARK Compressors have had wide acceptance in California, due to their fine record there for continuous operation.

When the demand for compressors for Hi-Octane Gasoline developed, CLARK delivered the goods. Not a single shipment has been late.

Today, with the advent of deeper fields and lighter crudes, California operators are producing large volumes of gas and are in position to make use of the advantages that accrue from pressure maintenance. CLARK deliveries to California in the past 4 years, principally for refinery and pressure maintenance service, have totalled 73,040 Horsepower. Half of that total was shipped in 1943.

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CLARK Sets the Pace in Compressor Progress

(Continued from Page 153)

immersed in a tank of oil. The unit is structurally mounted for access by lowering the tank. Lowering and raising the tank is accomplished by using a demountable hand windlass.

Fig. 6 shows an installation of such units with 2300-v. motor starters of similar construction. Units of this form are available in ratings up to 1200 amp., 5000 v., with interrupting ratings of 25,000 and 50,000 kva.

Oil immersion of all arcing parts and connections makes this equipment safe for operation in hazardous atmospheres and at the same time provides the most effective protection against corrosive atmospheric elements. Designed for location without regard to weather protection it requires no building construction and is extremely flexible as to layout. Equipment of this type has three distinct handicaps, however. First, is high cost. Second, this construction is not readily adaptable to inclusion of instrumentation and precision relays. Third, it is comparatively difficult of access for routine inspection and maintenance, a disadvantage more pronounced when such work must be performed on outdoor installations in inclement weather.

Although well built and properly applied switchgear requires little maintenance, it is important that when such work is required it be performed with convenience and dispatch. From this standpoint the construction known as "metal-clad, vertical-lift" is recognized as having outstanding advantages. In this form the oil circuit breaker, which is the heart of the unit, is readily removable from the structure by lowering onto a transfer truck. If desired it then can be transferred to a test rack where inspection of contacts can be made. The test rack also provides control circuits, permitting the breaker to be put through its normal operations with complete access for checking its action and making any necessary adjustments or repairs. While this work is being carried on an interchangeable spare breaker can be substituted in the switchgear housing thus limiting the total circuit outage time to a few minutes. Fig. 7 illustrates the convenience of inserting a circuit breaker into vertical-life switchgear of standard design.

This type of construction has demonstrated its advantages in broad industrial use. Obviously, its adaptation for locations involving corrosive and hazardous atmospheres has received active engineering attention.

One approach to the problem has been the use of essentially conventional design with the external doors and covers gasketed and bolted to effect a vapor tight enclosure. This construction is illustrated in Fig. 8, left. It does not provide a satisfactory solution. In applications involving large perimeters gaskets afford very imperfect protection against corrosive elements. They deteriorate rapidly with repeated opening and closure of the housing. There is also the inconvenience of manipulating a large number of holding bolts. Obviously, standard indicating instruments and relays mounted in the conventional manner are inadequately protected.

Fig. 7. For high-voltage circuits, metal-clad switchgear with removable circuit breakers is the most convenient type to install and to maintain, and the safest type to operate. In conventional designs, however, it is not suitable for use in corrosive and hazardous atmospheres

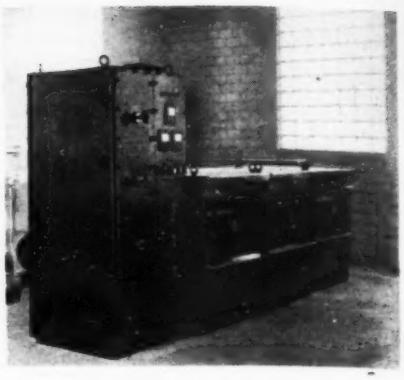

Fig. 8. In this installation switchgear units of gasketed construction operate in conjunction with oil-immersed motor starters

The advantageous features of vertical-lift metal-clad switchgear are retained in the construction shown in Fig. 9. In function, general arrangement, accessibility, and external appearance, this equipment is quite the same as standard metal-clad switchgear.

The degree of protection against hazardous gas conditions is not as high as that afforded by completely oil-immersed equipment, in that the protection does not apply to all live parts and connections. All parts subject to arcing in normal operation and all instruments and relays, however, are either oil immersed or in oil sealed or explosion proof housings.

The group of units shown in Fig. 9 consists of an incoming line unit (left) and 2 pairs of units for the control of 2 synchronous motors. Viewed externally, the most noticeable departure from usual practice is the mounting of the instruments, relays, and indicating lights. These are enclosed within a bell mounted on the rear of the main panel as shown in the upper portion of the open panel at the extreme left. The bell has an oil seal at the bottom, through which pass the conductors carrying circuits to the instruments, relays, and indicating lights. For visibility it has a high strength plate glass front that is permanently sealed to the bell.

The circuit breaker control switch is equipped with a conventional handle on the front of the panel, but its contacts are immersed in a small individual oil tank as seen on the rear of the open panel. The circuit breaker is shown on the dolly used to withdraw it from the unit. Its oil-immersed auxiliary switch can be seen immediately in front of the lower portion of the breaker tank.

Protection of the main disconnecting contacts of the breaker is of special interest. This is accomplished by mount-

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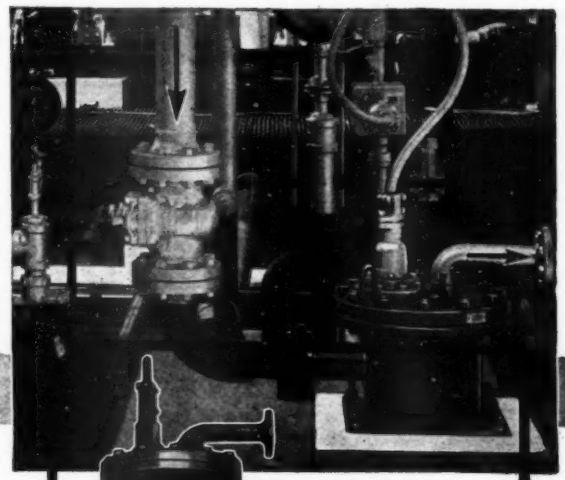

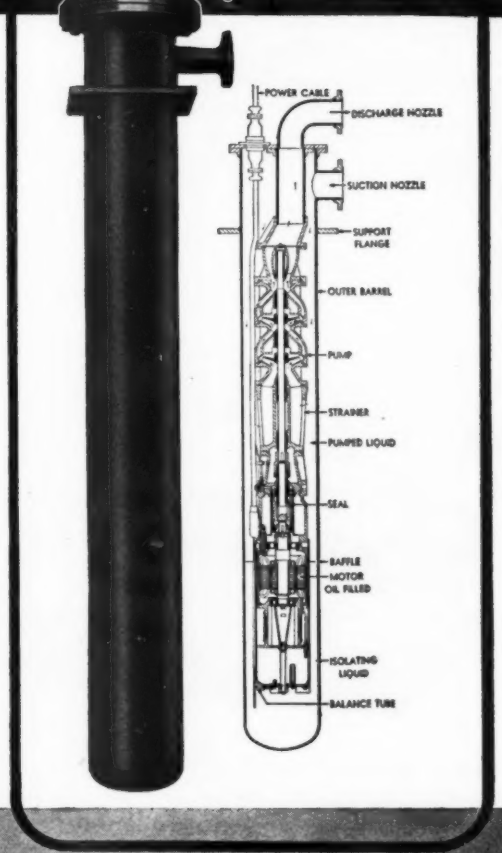

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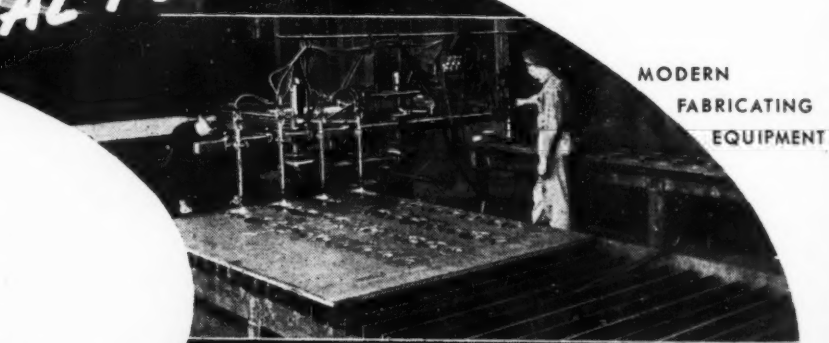

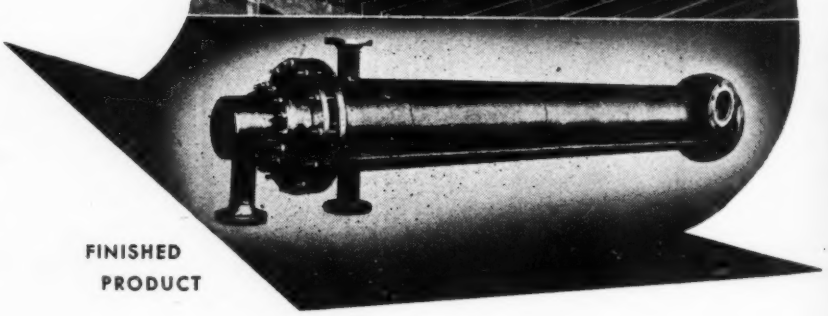

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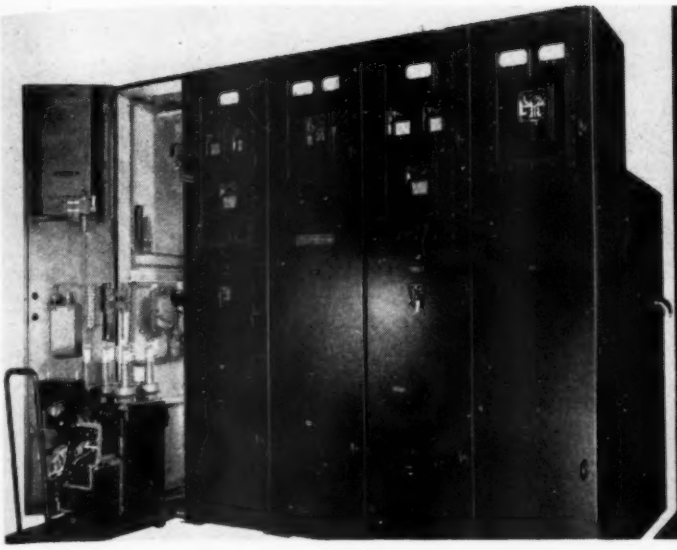


Fig. 9. This metal-clad switchgear has advantages of standard switchgear with protection of delicate parts against corrosion and of arcing parts against hazardous atmospheres

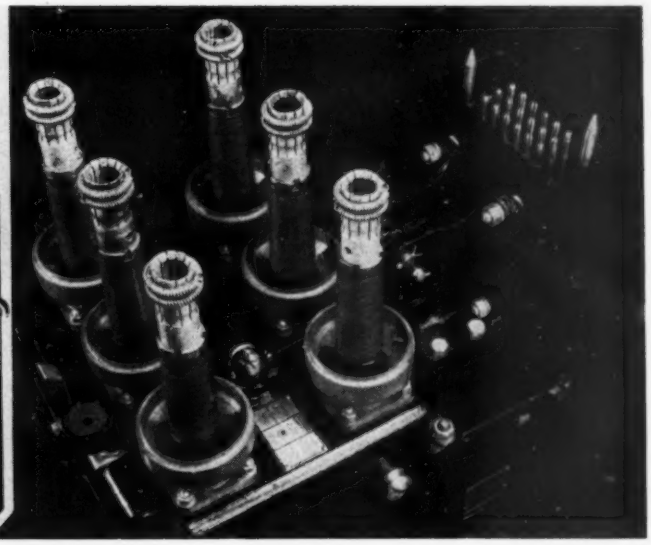


Fig. 10. Oil seals isolate the disconnecting contacts carrying power and control circuits when the breaker is installed in its unit

ing a Micarta cup at the base of each bushing as shown in Fig. 10. Each cup, filled with oil, forms a seal at the bottom of the cylindrical insulating chamber in which the stationary breaker contact is mounted. As the breaker is elevated into its operating position the 6 disconnecting contacts engage the 6 stationary contacts and simultaneously the oil seal is closed at the base of each bushing.

The disconnecting contacts of the control circuits are mounted as a group in a small oil tank and they engage corresponding stationary contacts as the breaker is elevated to its operating position. The elevating mechanism is operated by a crank, which engages the end of a shaft flush with the front of the panel. This shaft is accessible through a small hole in the panel when the latter is closed.

In Fig. 11a can be seen the breaker ready to be raised to its operating position. Also seen are the two auxiliary relays that control the breaker closing mechanism. These relays are normally immersed in an oil tank here shown in its lowered position. This view also shows the rear of the instrument and relay panel, normally covered by the oil-sealed bell, which is shown on the floor. Fig. 11b shows the breaker in operating position and the instrument panel, control switch, and auxiliary relay panel with enclosures in place, ready for operation.

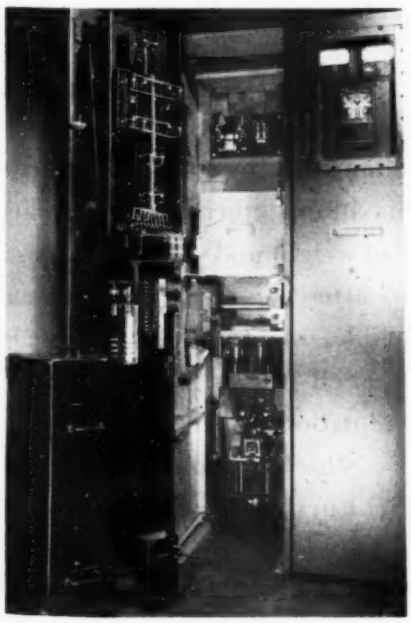
Each synchronous motor control consists of two adjoining units, one containing the oil-immersed field contactor, the field control relays, and field ammeter. The other unit contains the a-c. breaker, relays, and a-c. ammeter, which are arranged in a manner similar to the incoming line breaker.

Mechanical interlocking insures that each breaker must be tripped open before it can be lowered from its operating position in the cell, and thus prevent opening the circuit on the disconnecting contacts.

The high voltage bus and the stationary disconnecting contacts for each breaker are inaccessible except by removing bolted-on steel plates. This insures against accidental contact by the operator with high voltage parts, an important safety feature. At the same time, the low voltage control wiring, relays, and instruments are readily accessible for speedy performance of checking and maintenance work. Of course, disassembly or reassembly of protected parts and operation of such parts without their protection must be done only when the surrounding atmosphere is non-hazardous.

Thus the advantages of vertical-lift metal-clad switchgear are combined with protection of current-carrying parts and delicate mechanisms against corrosion; also with protection to all normally arcing parts against hazardous atmospheres that may occur while the equipment is in operation.

—— ☆ ☆ ☆ ——



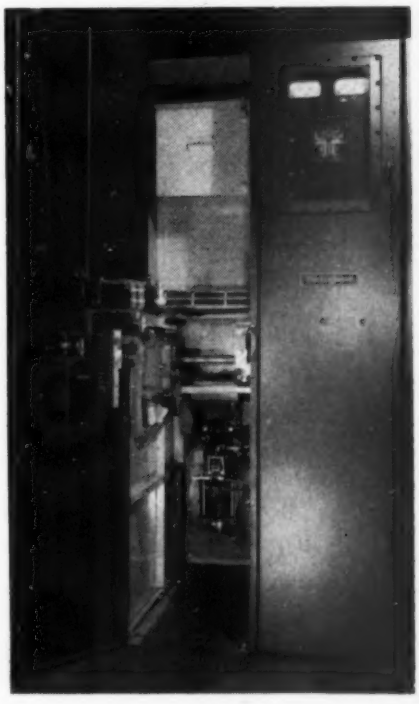
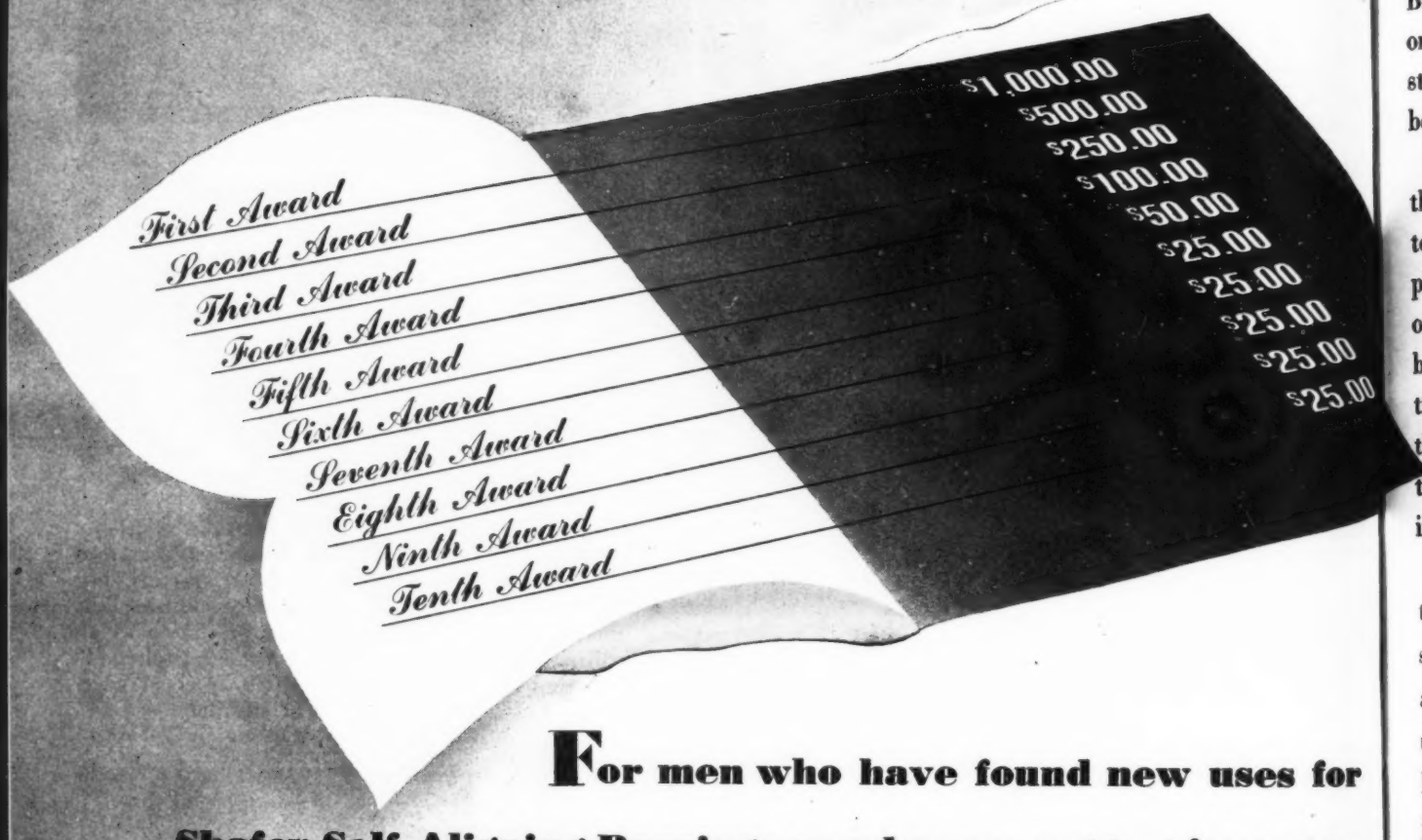


Fig. 11. Breaker disconnecting contacts, auxiliary relays, control switch, instruments and protective relays are exposed in (a) at left, and enclosed in (b) at right

Announcing the



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Any and all persons shall be eligible for participation in Shafer Achievement Awards and there are no restrictions as to the number of entries which any person may make. There are no limitations as to the form in which ideas may be submitted, providing only that the ideas or suggestions are set forth in a clear and understandable manner. All entries received at the headquarters offices of Shafer Bearing Corporation, 1426 W. Washington Blvd., Chicago 7, Illinois, on or before September 1, 1944 will be eligible. Awards will be made as soon as possible thereafter and award winners notified by mail and through announcements in magazines of national circulation.

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California Synthetic Rubber Project Is Now Completed

PETROLEUM ENGINEER EXCLUSIVE Feature

☆ Plants are producing about 90,000 tons of GR-S rubber per year, one-eighth of U. S. capacity

by Wallace A. Sawdon

Pacific Coast Editor

WITH the recent completion of all plants for the manufacture of butadiene from petroleum products, the California synthetic rubber program is now producing GR-S rubber at approximately its rated capacity of 90,000 tons per year. This is one-eighth of the rated capacity of the present program for this type of synthetic rubber in the United States. It is expected, however, that the actual production of the California project will exceed the rated capacity appreciably.

The plant manufacturing styrene, the other chief ingredient of buna-S, or GR-S (government rubber—styrene type) rubber, as it is called, has been in operation for more than nine months and during this time has been shipping its products to other synthetic plants in the country in addition to furnishing styrene for the California project as units have been completed and put into operation.

The project is concentrated in and around Los Angeles and was planned to take advantage of existing facilities to the greatest extent possible. It is a highly integrated chemical process in which six individual plants are linked together for a continuous flow of petroleum products, benzene, and alcohol through butadiene and styrene to the polymerization units of the co-polymer plants where the raw rubber is formed. This flow of products is indicated schematically in Fig. 1.

During construction of the units as much salvaged or second-hand equipment and material as possible was utilized but no sacrifice in efficiency or most advanced design was made. Many of the boilers, for example, were taken from old destroyers of the first World War. These being marine boilers, treating plants for the feedwater naturally had to be installed. All plants have been made as nearly automatic as possible by means of instrument control and the manpower required for operation has been cut down to the minimum.

Butadiene Plants

Butadiene for polymerization with styrene originates at three different plants. At one plant pure butadiene is processed and goes direct to the polymer units; but crude butadiene and/or butylene made at the other two plants go to a chemical plant for treatment before being piped to the co-polymer plants.

Pure butadiene is made in a Houdry type plant at Standard Oil Company of California's El Segundo refinery and is shipped in pressure type tank trucks direct to the rubber plant. This plant was built for the Defense Plant Corporation and is operated by Standard for the Rubber Reserve Company. Construction was begun in March, 1943, and first production was in January, 1944.

The manufacture of butadiene in this operation begins with butane, which is first dehydrogenated by removal of four atoms of hydrogen from each molecule. Extremely high temperature is required for one phase of the process, after which the gases are compressed to liquid form. The butadiene, a gas at atmospheric pressure but a liquid under high pressure, is extracted from this fluid. An extensive cooling system is required to cool the butadiene mixture from its high temperature. Water for the cooling system is pumped from the Pacific Ocean, a mile away.

At another stage of the process air at high temperature is blown through the reactors where the conversion to butane takes place, the flow of air being at a rate of 80,000 cu. ft. per min. or 360,000 lb. per hr. This air is previously purified by electrostatic filters, which remove any dust that might affect the action of the catalyst used to bring about the conversion. Heat from this air is recovered in high pressure

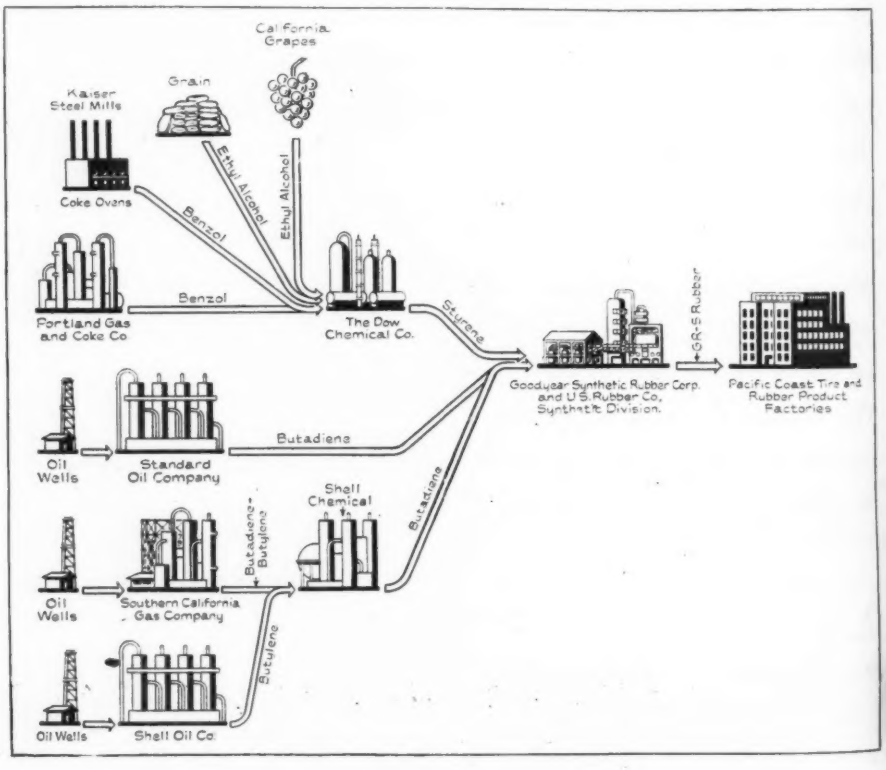

Fig. 1. Steps in the California synthetic rubber project

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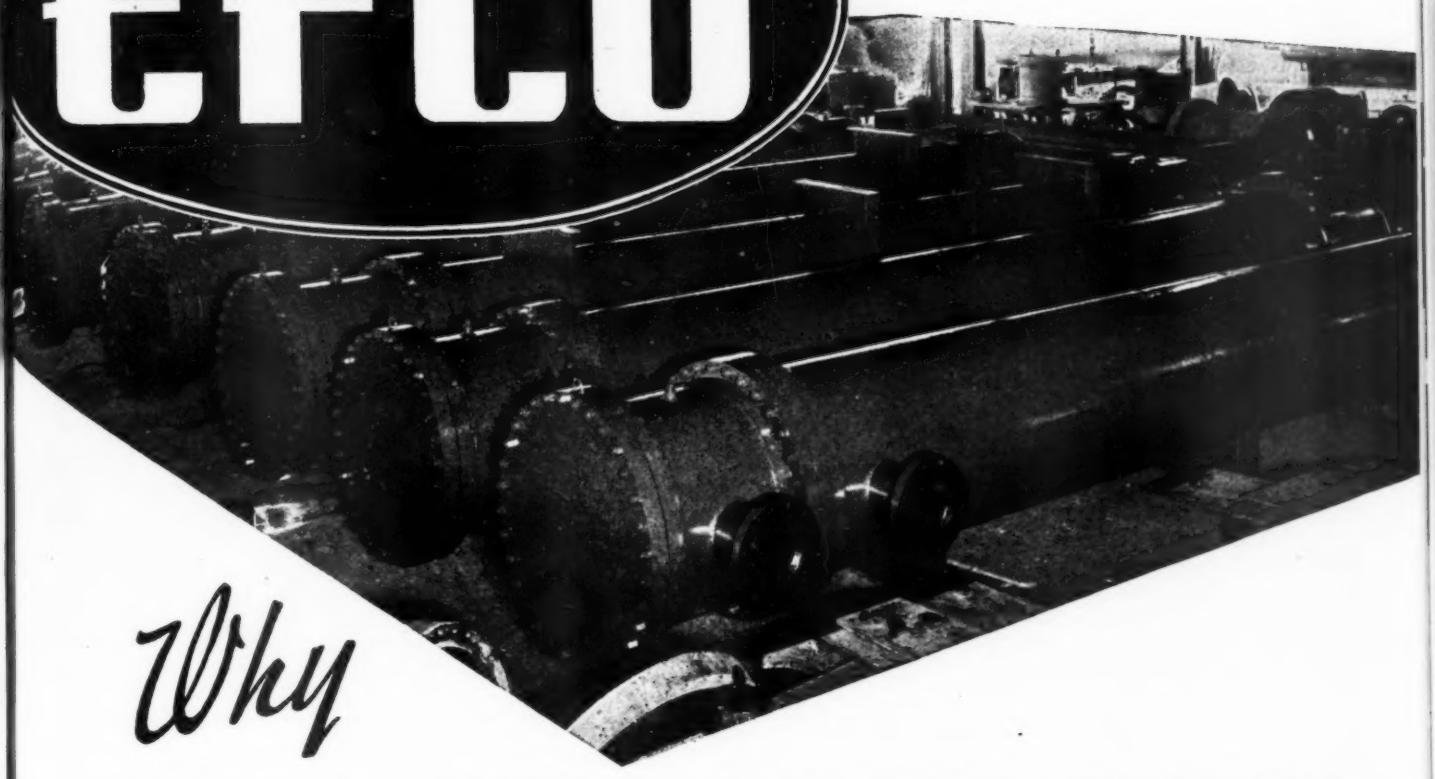

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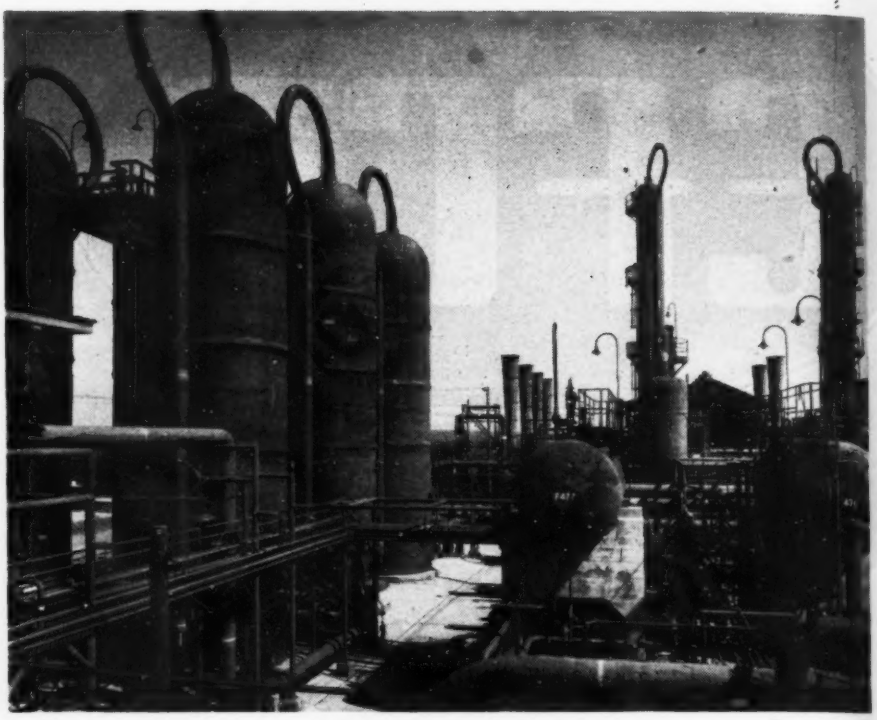


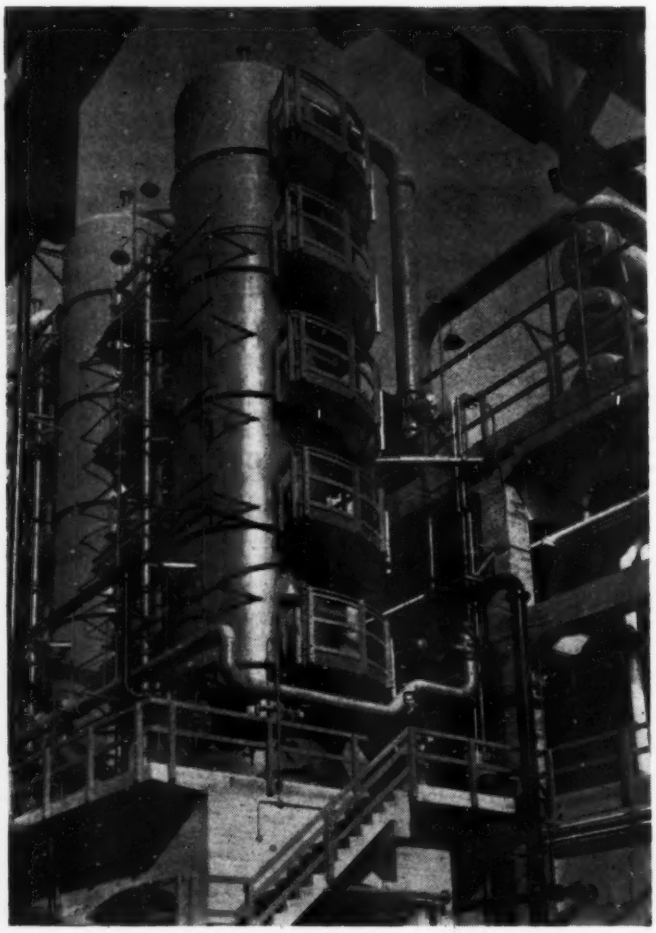
boilers where it generates 55,000 lb. of steam per hr. for operation of pumps and for process heating.

The compressors handling the various gas streams in the process total 7500 hp. The compressor installation is the largest in the west.

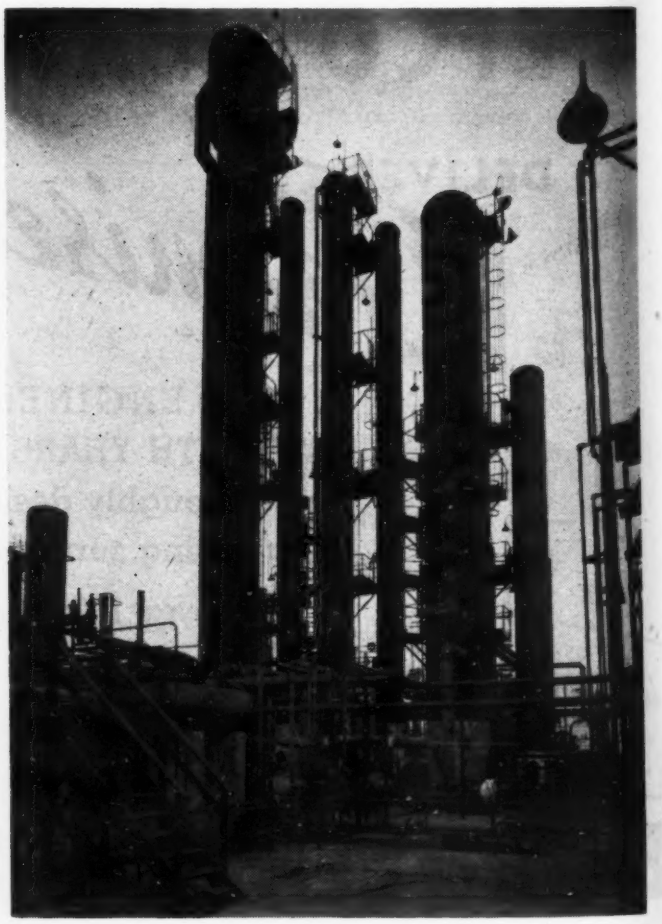
Crude butadiene and butylenes are recovered at the Southern California Gas Company plant in the city of Los Angeles and are piped for further treatment and purification to the Shell Chemical plant near the Shell Oil Company refinery at Dominguez. The gas company plant is a converted installation, having been a standby plant that manufactured gas and it utilizes a great amount of existing equipment. This plant went into operation in June, 1943.

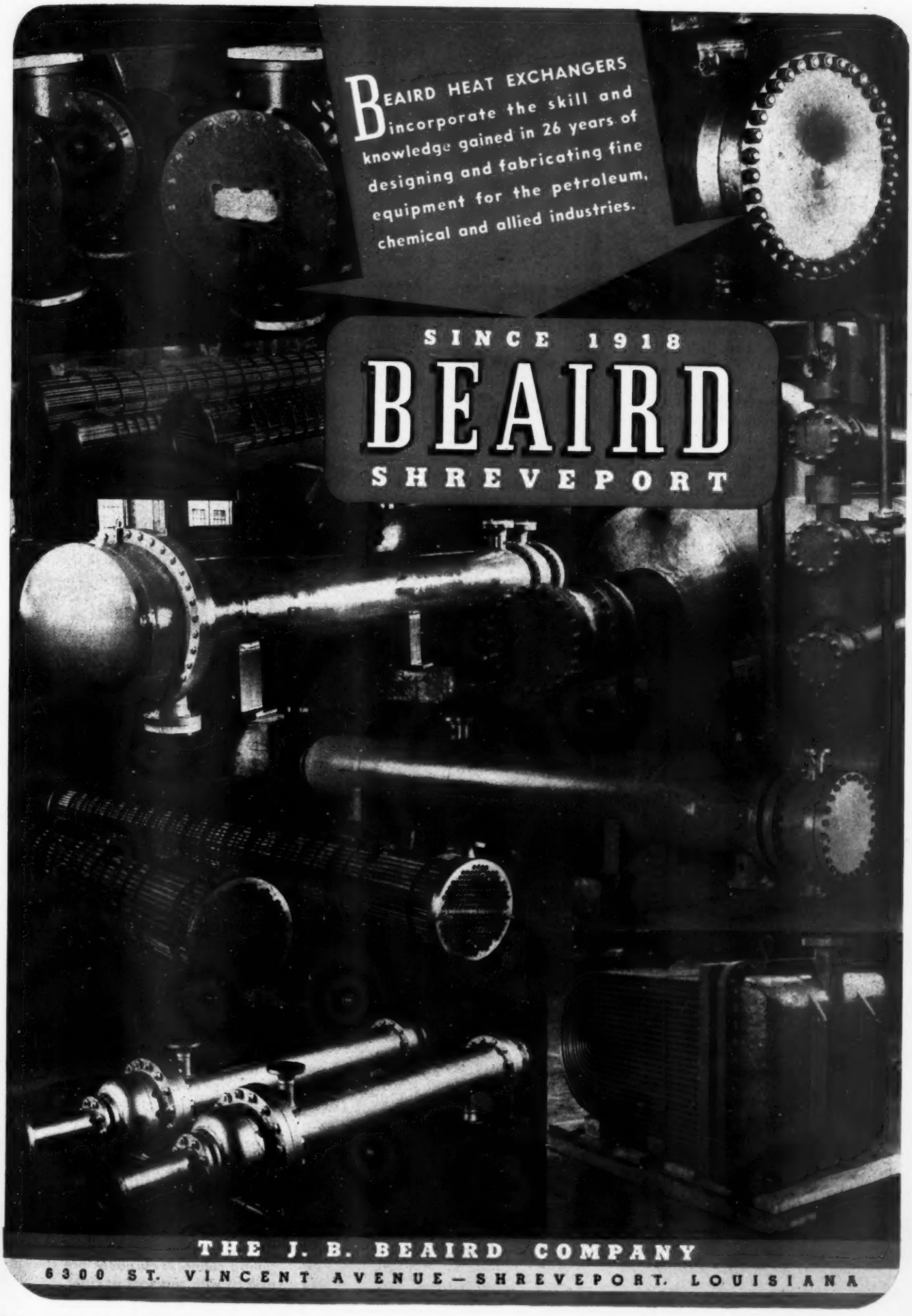
The process used at this plant consists of cracking oil distillates and obtaining a petroleum fraction composed of various hydrocarbon chains containing four carbon atoms. This C_4 cut includes butane, butylenes, and butadiene. The crude butadiene and butylenes are recovered by conventional absorption methods from the gases produced by the petroleum vapors and this fraction goes to Shell Chemical for purification. The other ingredients obtained as by-products are used in the manufacture of fuel gas, fuel oil, and gasoline. The gasoline blend stocks are recovered from the liquid products by processing in the dehydration plant and are shipped by pipe line to the Shell re-

A part of recovery area for unreacted styrene, Goodyear and U. S. Rubber plant at Los Angeles



Extraction towers in Standard's butadiene plant. Extractor (left), butadiene rerun column, depropanizer

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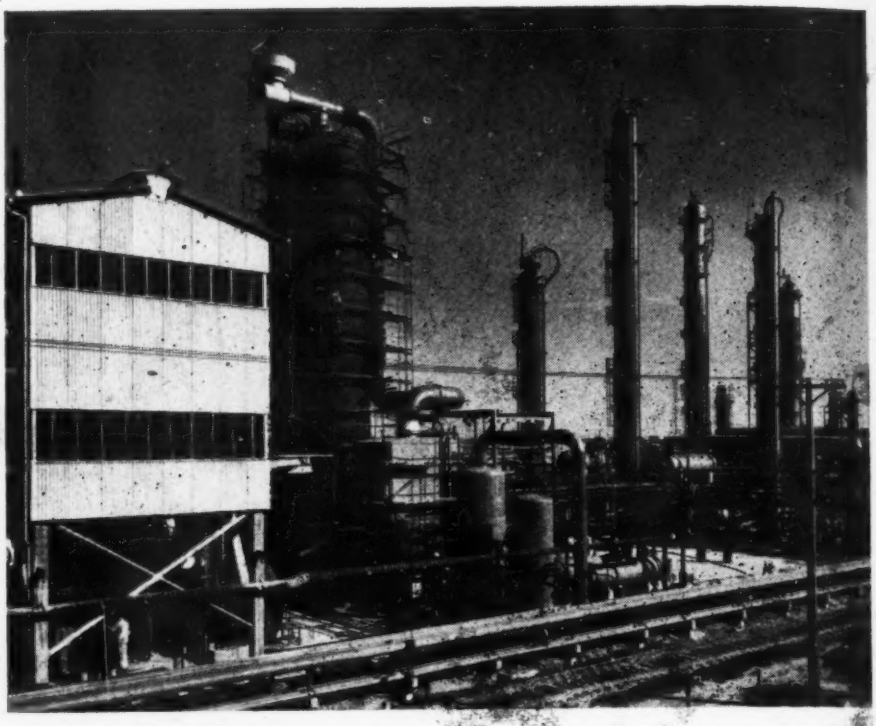
finery where they are hydrogenated to high octane aviation gasoline or used for gasoline blending.

The oil distillates are obtained from refineries of Shell, Associated, Wilshire, Texas, Union Oil, General Petroleum, and Standard. These distillates are high in sulphur content and the sulphur is partly converted to hydrogen sulphide in the generators. As hydrogen sulphide is undesirable in both the plant and the gas company mains, it is removed by passing the gas through oxide boxes. These boxes, packed with wood chips coated with iron oxide, are the largest in the world and each holds approximately 50,000 bu. of the coated chips.

Shell Chemical is a combination butadiene-purification and butadiene-manufacturing plant. The C_4 fraction received from Southern California Gas Company, consisting mainly of crude butadiene and butylene, also contains a trace of acetylene that must be removed. This removal is the first process and is accomplished by conversion to other components. The resultant butadiene-butylene mixture is then fed into an extraction system where the butadiene is separated from the butylene.

The butylene here recovered is combined with a butylene-butane mixture piped from the Shell refinery nearby. The combined mixture of butylene and butane flows into a cold acid unit where, with sulphuric acid being used as a catalyst, *iso*butylene is extracted. The *iso*butylene is then polymerized and di-*iso*butylene and heavy polymers taken off are sent to the Shell refinery for use in the manufacture of aviation gasoline.



Shell's catalytic dehydrogenation unit, which splits butylenes into butadiene and hydrocarbons

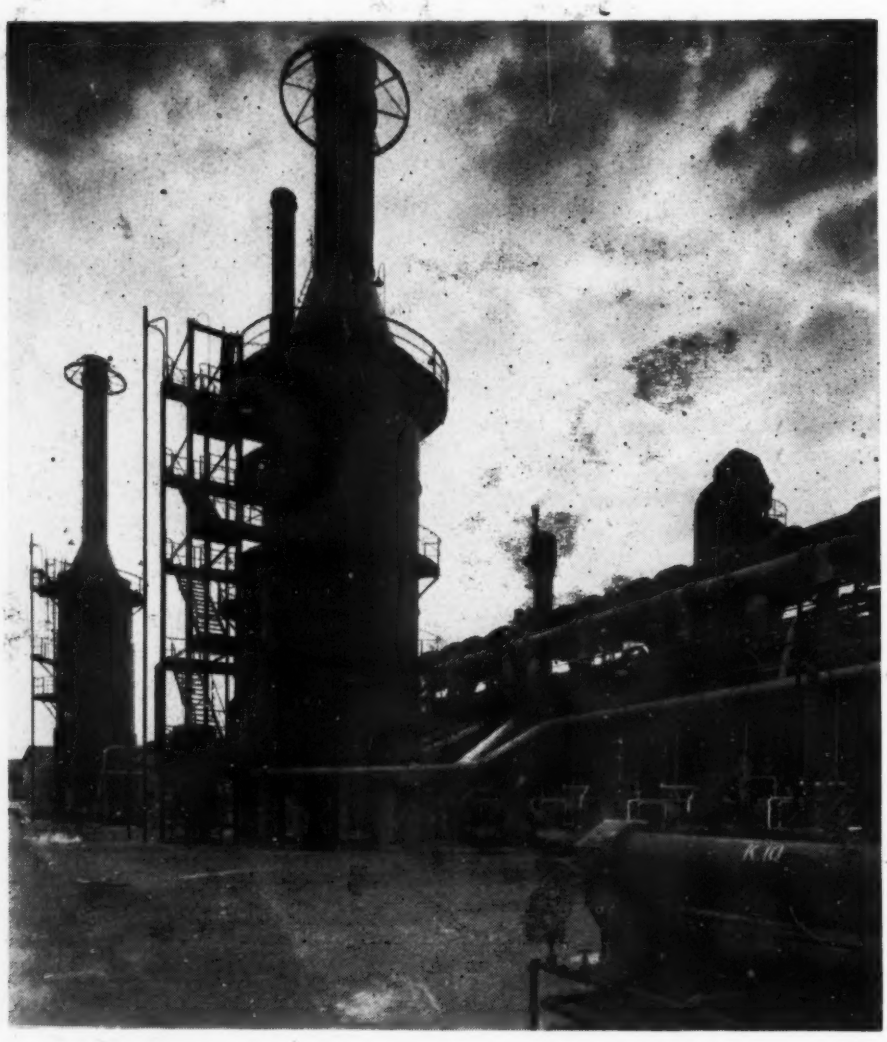
The butanes and normal butylene recovered by this process are sent through an extraction unit where the butanes are removed. These butanes are also piped to the refinery for use in the making of aviation gasoline.

The normal butylenes are converted into butadiene by a catalytic process and this butadiene is combined with butadiene from the Southern California Gas Company. The combined butadiene is then purified in the butadiene extraction unit and piped to the co-polymer plants where it is converted with styrene into GR-S rubber.

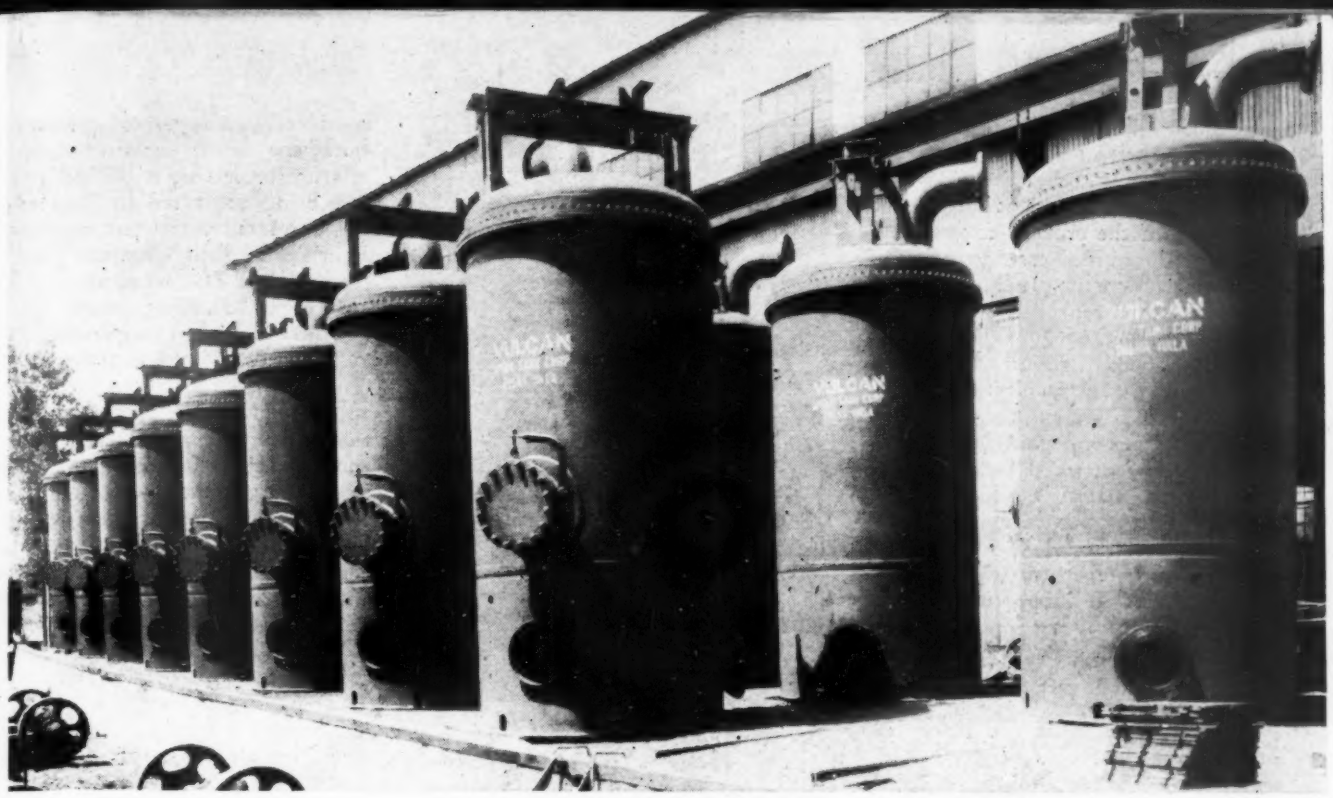
Styrene Plant

The Dow Chemical Company styrene plant was completed in June, 1943, the first unit of the California synthetic rubber project to go on production. At this plant ethyl alcohol and benzol are converted into styrene.

In two ethylene units 95 per cent pure alcohol is cracked by passing the vapors, mixed with steam, over a china clay catalyst heated to the temperature of melted lead. After suitable purification and completion the ethylene gas



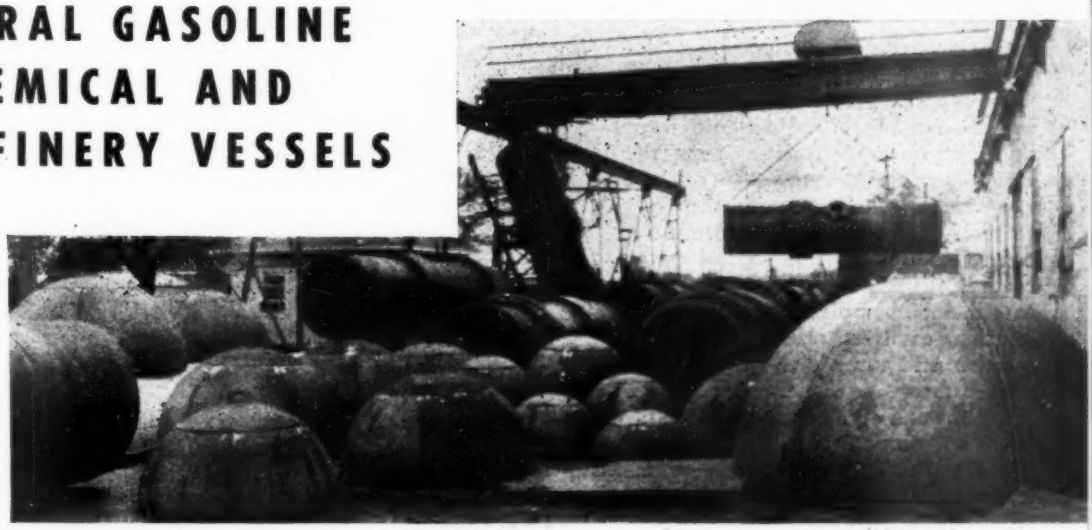
Standard Oil Company of California's Houdry type butadiene plant at El Segundo refinery. Furnaces are shown at left, with reactors at right



Battery of Turbo-Mixer Vessels to be employed in the processing and manufacture of high-test Aviation Gasoline. 6' 6" diameter by 18' high. 1¾" flanges.

VULCAN Light and Heavy Steel Pressure Vessels

NATURAL GASOLINE CHEMICAL AND OIL REFINERY VESSELS



RECOGNIZED for complete and most modern equipment, skill acquired with long experience and facilities for special intricate forming—VULCAN is furnished many of the most vital units for the war effort in Chemical, Synthetic Rubber and Aviation Gasoline Plants throughout the country.

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TULSA, OKLAHOMA

PLANT: North Harvard and Frisco R. R. Telephone 5-2101

goes to the ethyl benzol plant, where it is combined with benzol under proper conditions to give ethyl benzol, which is highly purified before passing to the next stage of the process. Excess ethyl benzol produced is diverted to refineries for use in 100-octane gasoline plants.

In the ethyl benzol cracking units the purified ethyl benzol is mixed with steam and cracked at high temperature over a catalyst to produce crude styrene. The crude styrene then passes to the styrene finishing units in which it is purified and prepared for shipment. Unconverted materials are separated and returned to proper units for re-running.

One by-product of the styrene plant is toluene, which is shipped to munition plants for the manufacture of TNT or to aviation gasoline refineries, depending on the current need for either product.

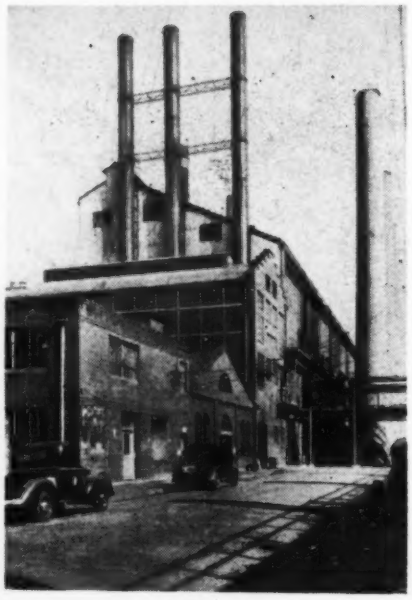
All boilers in use at this plant for steam generation were originally destroyer boilers so the feedwater is completely softened by a water treating plant. The steam generated here supplies both the styrene plant and the co-polymer units located adjacent to it.

Rated capacity of the styrene plant is sufficient to produce 100,000 tons of GR-S rubber per year, but the plant has actually operated successfully at rates above that.

Co-Polymer Plants

Three polymerization plants, with a total rated capacity of 90,000 tons of synthetic rubber per year, are operated by the Goodyear Synthetic Rubber Corporation and the United States Rubber Company, synthetic division. The liquid styrene and butadiene in liquid form under pressure are received from the other plants and the proportion of these raw materials and assisting chemicals to meet a precise chemical formula is controlled in a central control meter room in the reactor areas. The ingredients include butadiene, styrene, a soap solution, catalysts, other chemicals in solution, and water.

Preparatory to polymerization, the butadiene and styrene are emulsified in the soap solution by whipping them into small droplets. Starting polymerization, the temperature of the batch is raised and controlled by water jackets from the reactor. As polymerization proceeds, the droplets become more viscous and more rubber-like. The emulsion is then no longer that of an oil in liquid but of a soft solid in a liquid. This is now a synthetic rubber latex.



The gas plant of Southern California Gas Company in Los Angeles, converted last year to the manufacture of butadiene, is capable of producing about 35,000 tons annually

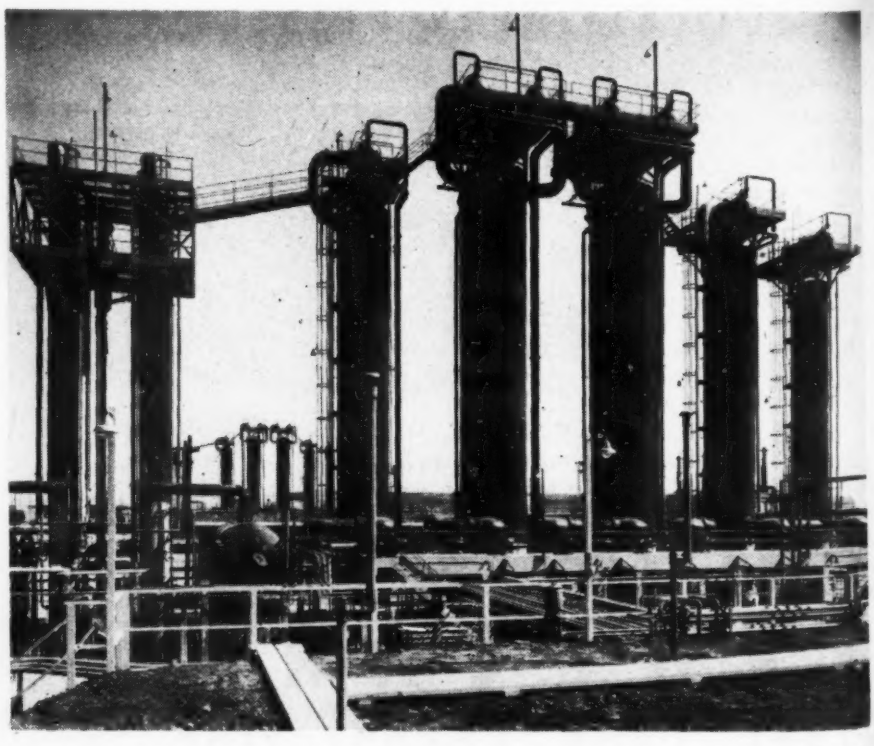
The progress of the reaction is carefully checked and when polymerization has reached a specified point a chemical is added to arrest further polymerization and the batch is run off into blow-down tanks. In the blow-down tanks the synthetic rubber latex is tested. Hydrocarbons that have not combined are recovered, the volatile butadiene being separated from the mixture by letting it boil off as a gas and being recovered by compression. All unreacted petroleum materials are returned to Shell Chemical plant for reprocessing. The excess styrene is recovered by distilling under reduced pressures at higher temperatures.

The batch of latex, containing 25 per cent synthetic rubber, is treated with an antioxidant that prevents deterioration. A number of batches are bulked and blended for uniformity of product in 30,000-gal. tile-lined concrete storage vats. The latex is then coagulated by salt and acid and the small particles coalesce as larger flocs. Rock salt to the amount of 70 tons per day are consumed.

After coagulation the rubber flocs are filtered, washed, and then pressed to remove excess water, the rubber being dried by passing back and forth three times in large continuous driers. The 12 driers in the plants evaporate 160 tons of water per day. The dried rubber is then weighed on automatic scales, which feed 75 lb. of rubber to automatic bailers where this quantity is pressed into loaves 14 in. by 28 in. by 7 in.

For process control and to insure a uniform product, approximately 1800 samples of various kinds are taken and tested daily in the chemical and physical laboratories installed in the polymer plants. The loaves of GR-S rubber, in protective wrappings, are shipped to the rubber manufacturers for processing into finished articles by the same machinery employed for natural rubber.

☆ ☆ ☆



The Dow styrene finishing unit. These towers separate the finished styrene from a liquid mixture of styrene, tars, and other hydrocarbons. The styrene is piped to the rubber companies, most of the remaining hydrocarbons being piped back to earlier stages in the process ultimately to make more styrene

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Modern Pressure Vessel Design And Construction Materials

☆ A plea for modification of regulations in keeping with present state of emergency

by Charles M. Scudder

Assistant Engineer, Pressure Vessel and Welded Parts Division, A. O. Smith Corporation

THE history of the pressure vessel industry shows that most advances have been made by progressive manufacturers seeking new ways to produce a better product at lower costs. Constant additions both to the theoretical and the practical knowledge of stress distribution for various shapes and loadings, together with marked advances in metallurgical knowledge, have provided splendid opportunities for increased economies in design.

There are, however, certain barriers existing, which although natural enough in their development, might possibly be likened to a brake that exercises a retarding influence so far as adoption of advanced practices is concerned.

The development of codes to control the design and construction of pressure vessels was logical from the standpoint of requiring the production of a safe product. Such codes met the needs of various regulatory bodies in that a code could be adopted as a standard accepted by the engineering societies and would have as a background the past performance of vessels built in accordance with code regulations. With expansion of our industrial activity, the need for such codes, especially for hazardous services, was very evident under competitive buying.

The evolution of commercial codes to cover pressure vessels, when viewed in the light of its acceptance of improvements, is not an unmixed blessing. As their scope increased, there developed a natural reluctance to make changes. As an additional hurdle to be overcome was the fact that, for the ASME Code in particular, every change had to have the unanimous approval of the code committee. The interpretation of the rules as written for special cases presents a continuous series of problems and the modification of some time-tried paragraph may produce surprising results even when it has been adopted after much deliberation. The ASME Code may, therefore, be considered as being based on a series of safe case histories rather than upon up-to-date developments incorporating the most recent technical progress.

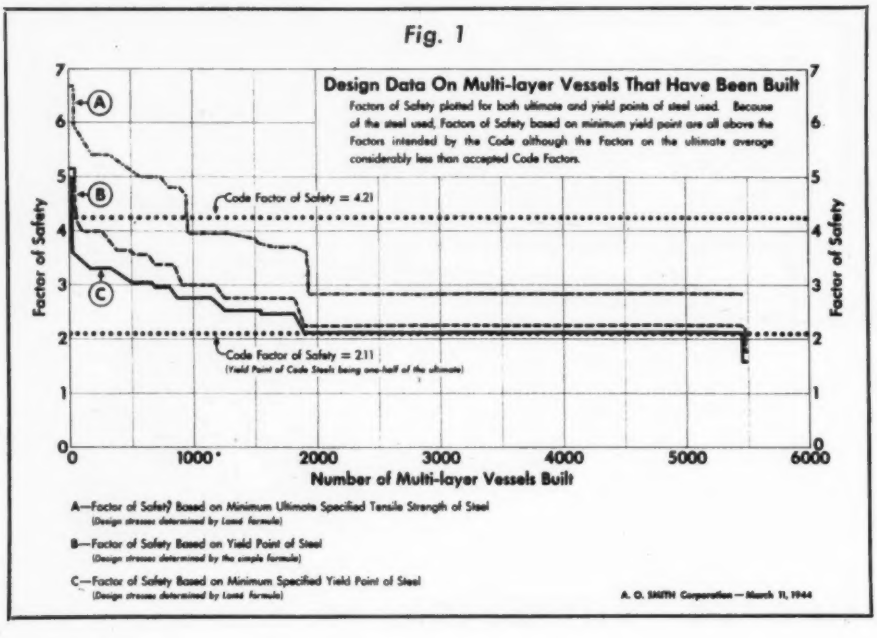
This is also true with respect to insurance companies, who are primarily interested in safety rather than with the conservation of metal or the reduction of weight. They are reluctant to approve the use of new materials or designs because of the lack of numerous case histories covering their application.

CHARLES M. SCUDDER holds degrees of B.S. in civil engineering (1911) and civil engineer (1912) from the University of Wisconsin—Engaged in field work and testing on hydroelectric projects for the Aluminum Company of America and after 2 years, returned to the University of Wisconsin as instructor in mechanics and strength of materials—During World War I served as captain of engineers—Later served successively with Allis-Chalmers Manufacturing Company and with the First Wisconsin National Bank and Wisconsin Bankshares Corporation before becoming a member of the A. O. Smith engineering department.

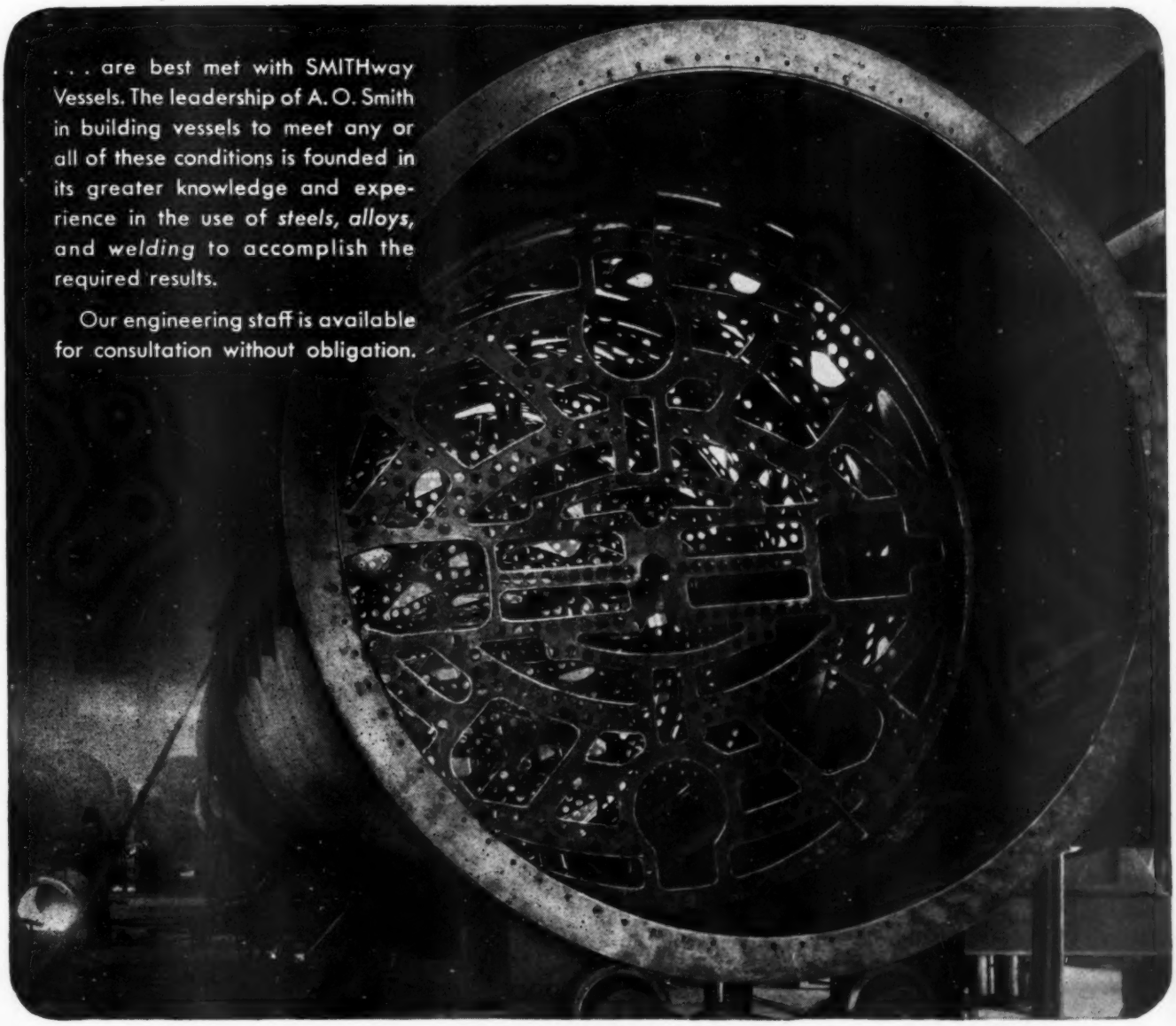
The history of multi-layer vessels is a case in point. The use of multi-layer shells for vessels came about through efforts to find a safer and more economical construction that would be particularly effective where thick walls were involved, and the ratio of vessel diameter to wall thickness was less than about 10 to 1. The demands for such vessels in recent years have been very great and the flexibility of layer construction has lent itself admirably to the working out of specific designs for various purposes. Such vessels designed to meet the desired requirements were primarily constructed to have factors of safety in accordance with existing codes or regulations in order to be acceptable for installation.

In special cases, where reduction in weight was essential or where code practice was not required and it was possible to take advantage of the construction to effect economy, a lower factor of safety upon the ultimate strength was used than has been permitted by the codes.

Fig. 1


Design Data On Multi-layer Vessels That Have Been Built
Factors of Safety plotted for both ultimate and yield points of steel used. Because of the steel used, Factors of Safety based on minimum yield point are all above the Factors intended by the Code although the Factors on the ultimate average considerably less than accepted Code Factors.
A
B
C
Code Factor of Safety = 4.21
Code Factor of Safety = 2.11
(Yield Point of Code Steels being one-half of the ultimate)
Factor of Safety
Number of Multi-layer Vessels Built
0
1000
2000
3000
4000
5000
6000
A—Factor of Safety Based on Minimum Ultimate Specified Tensile Strength of Steel
(Design stresses determined by Lamé formula)
B—Factor of Safety Based on Yield Point of Steel
(Design stresses determined by the simple formula)
C—Factor of Safety Based on Minimum Specified Yield Point of Steel
(Design stresses determined by Lamé formula)
A. O. SMITH Corporation — March 11, 1944

Conditions Involving High PRESSURES High TEMPERATURES and CORROSION . . .



. . . are best met with SMITHway Vessels. The leadership of A. O. Smith in building vessels to meet any or all of these conditions is founded in its greater knowledge and experience in the use of *steels, alloys,* and *welding* to accomplish the required results.

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Due to the relatively higher yield point of the steel used, the factor of safety on the yield point was, in nearly all instances, higher than the corresponding code value.

In order to indicate graphically the relationship between the factors of safety of multi-layer vessels built to date and the number of vessels produced, a chart was prepared as shown in Fig. 1. This chart gives the total number of vessels that have a factor of safety equal to or greater than a given value when readings are taken at the right end of any horizontal portion of the curve or at any point on an inclined portion. The above restriction on reading is due to the fact that numerous groups of vessels have the same factor of safety. If plotted to a sufficiently large scale, the graph would consist of a series of non-overlapping horizontal lines, each line length representing the number of vessels built with a particular factor of safety. The curves are not chronological in character because some vessels with a high factor of safety were produced contemporaneously with those that were made with weight as a primary consideration.

Multi-layer vessels are not yet recognized under the present ASME Unfired Pressure Vessel Code although a section covering them is under consideration, but for purposes of comparison two horizontal lines are shown upon the chart to represent factors of safety. The upper one shows the code factor of safety upon the ultimate strength of accepted steels under the ASME Code for Unfired Pressure Vessels of welded design as adopted during the national emergency. This is based upon a factor

(Continued on Page 176)

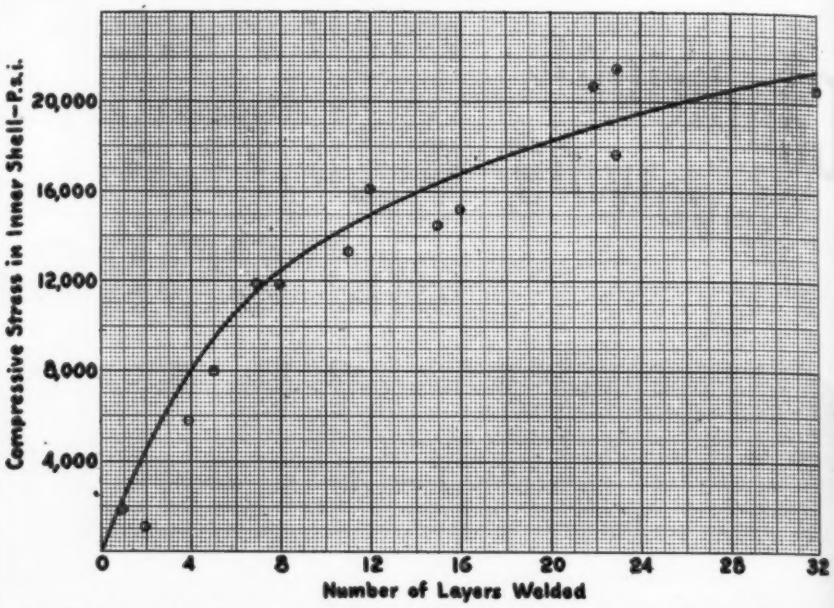

Fig. 2. Curve showing stress obtained from strain gauge readings taken on inner shell of a multi-layer cylinder section during fabrication. This was done to determine the increase in compressive stress in the inner shell as outer layers are added

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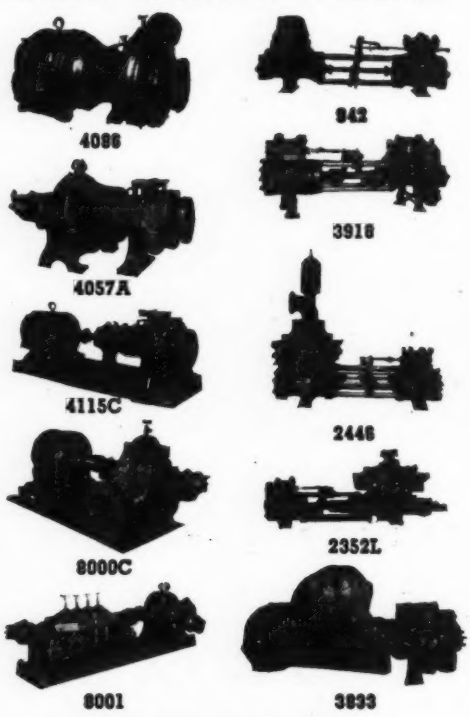

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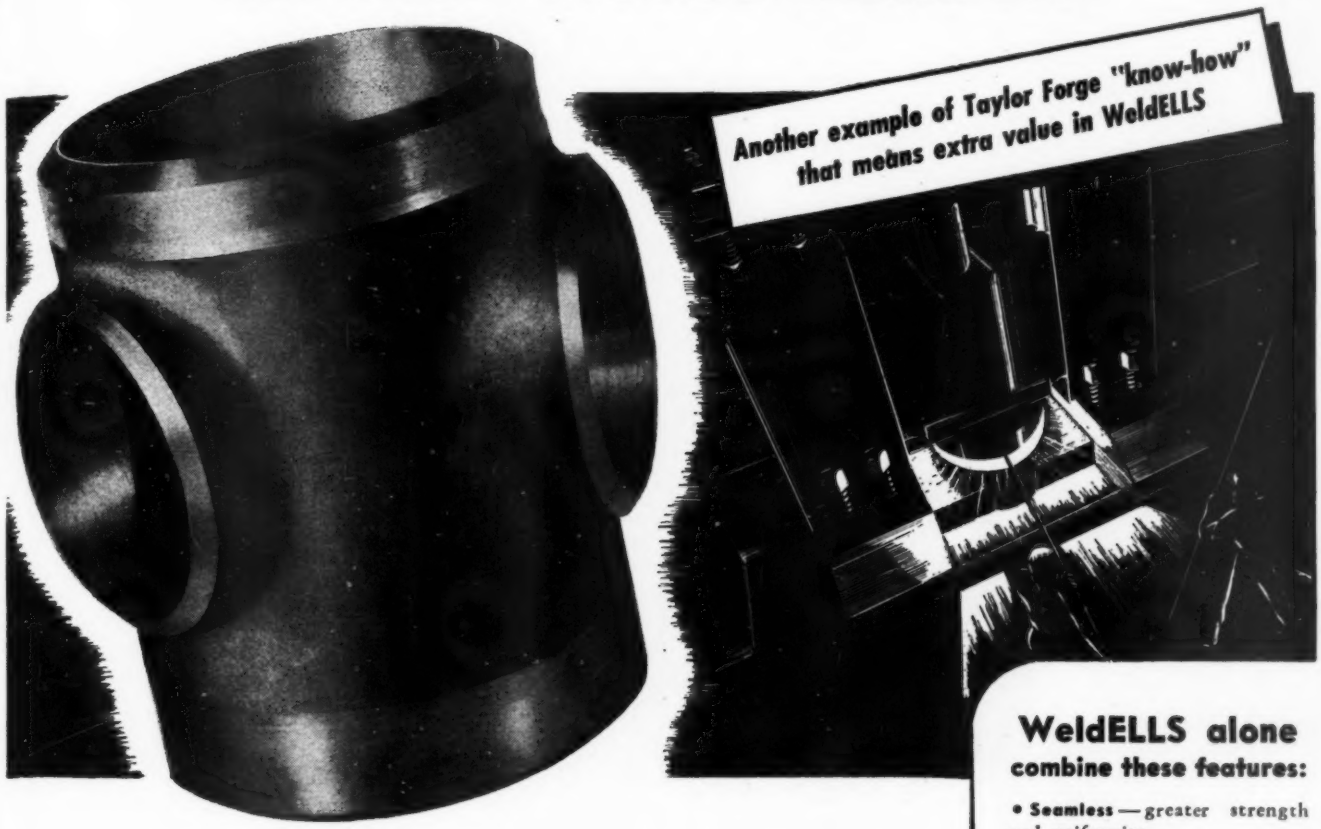

A side outlet tee? Hardly, because the included angle between the outlets is 120°. A cross? Well, what do you think?

Perhaps the best term would be "double branch tee". Anyway, it is formed seamless in carbon-moly—is 10" pipe size in the run with .605" wall, and 7" size in each branch with .429" walls.

This double-branch tee is just one of hundreds of examples of the endless procession of problems that we have tackled and solved across the years—many of them far more difficult than this.

No wonder, then, that we are able to give you extra values in our regular line of WeldELLS and other Taylor Forge welding fittings. There is nothing that can be desired in welding fittings which is not within the scope of our facilities, methods and experience . . . no desirable feature, in fact, that has not already been engineered into the Taylor Forge line.

That is why you find those added touches in WeldELLS like extra metal properly distributed where stresses are greatest . . . why WeldELLS have tangents . . . why dimensions are so extremely accurate . . . why they have features, listed opposite, that are combined in no other welding fittings . . . why, in the phrase that tells the story so well . . .

WeldELLS alone combine these features:

- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends** —simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
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- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

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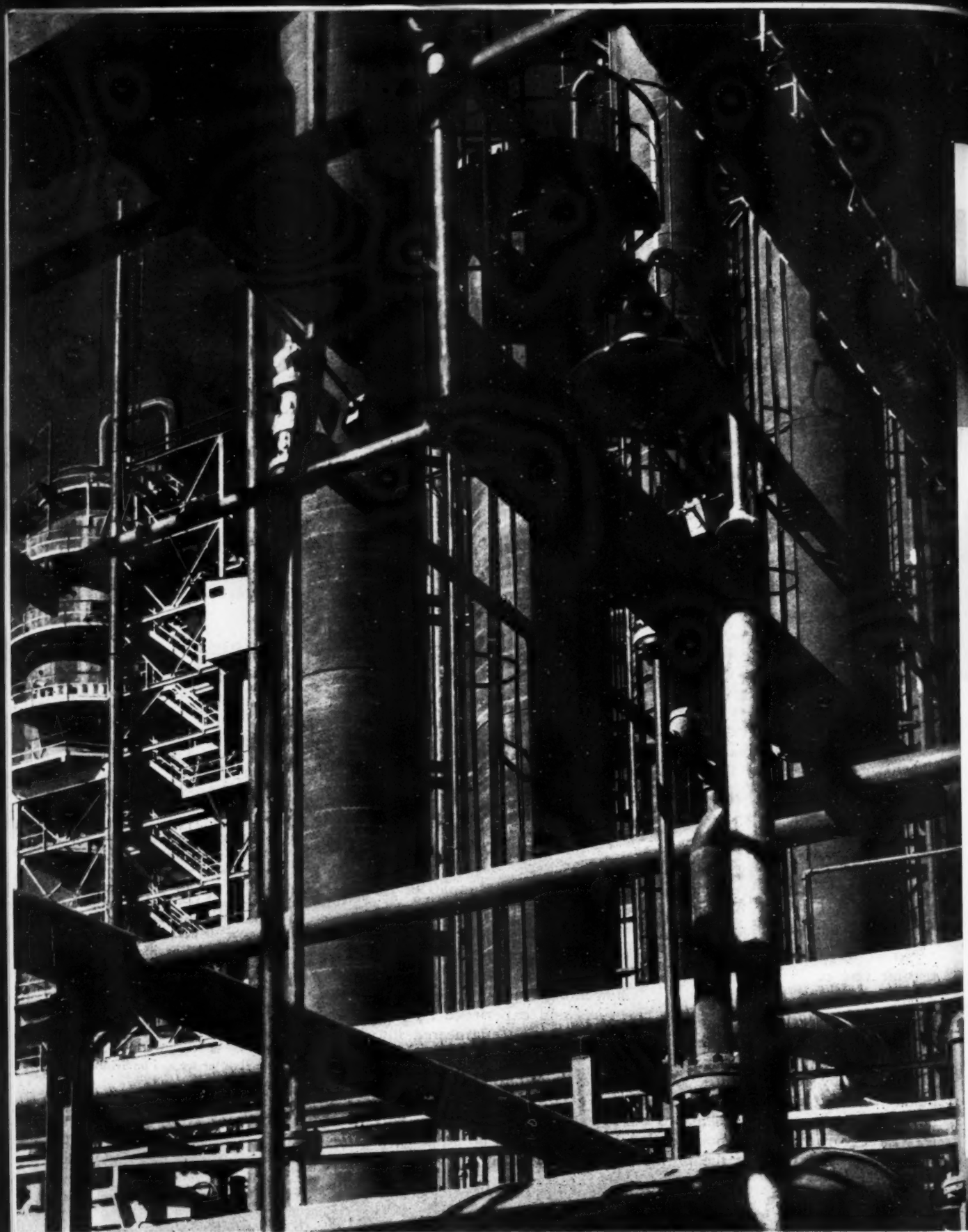

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Low initial capital outlay, smooth operation, maximum recovery of premium cuts at high thruputs—these are characteristic of the process plants we have engineered and built.

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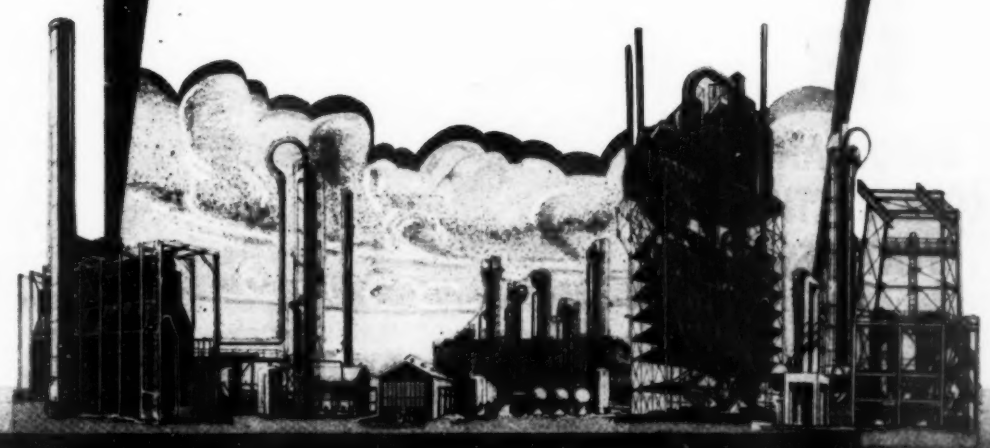
Our initial 100 octane aviation gasoline war program assignments, involving isomerization, fluid catalytic cracking, alkylation and the like, have been completed. We are now engaged in the new war program of recovering and separating pure hydrocarbon cuts of natural gasoline, and of repressuring our nation's crude reservoirs—steps to insure the greatest ultimate recovery of natural resources.



JONES & LAUGHLIN SUPPLY COMPANY

(Succeeding Frick-Reid Supply Corporation)
SUBSIDIARY JONES & LAUGHLIN STEEL CORPORATION
TULSA, OKLAHOMA

(Continued from Page 172)

of safety of four and a welding efficiency of 95 per cent, giving an overall factor of safety of 4.21. The corresponding factor of safety prior to the emergency modification was five with a welding efficiency of 90 per cent, giving an overall factor of safety of 5.55.

Existing codes do not formally recognize a factor of safety based upon the yield point, but the factor selected for the ultimate strength contemplated the use of steels whose yield point was about 50 per cent of the ultimate. The lower horizontal line is plotted at a value of 2.11, which represents the ASME Code factor of safety, assuming the yield point to be half of the ultimate strength.

A study of the curve that gives the factor of safety upon the ultimate for the multi-layer vessels built by this company reveals some interesting facts. The stresses were computed by the Lamè formula. Out of the total of 5451 multi-layer vessels built by this one company, only 106 had a factor of safety of 5.55 or over corresponding to the former ASME requirements; 709 would conform to an overall factor of safety of five or more, which has been the API-ASME requirement for unstress-relieved and unx-rayed vessels for some time, and 936 vessels would conform to or exceed the present national emergency requirements of the ASME. These vessels represent various classes of service.

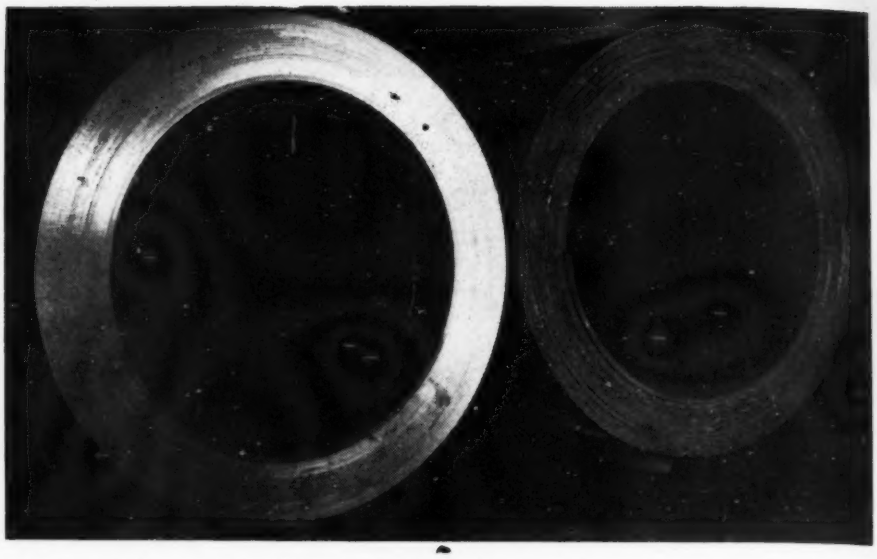


Fig. 3. End view of multi-layer shells made of 22 layers, equivalent to a total wall thickness of about 6 in. On the right is a shell section before machining. On the left is a similar section with welding scarf machined

The long horizontal line corresponding to a factor of safety of 2.86 represents high pressure vessels for compressed gases, which were designed primarily to save weight but which from the nature of their service must be safe. If they had been designed to the code national emergency standards, their weight would have been increased nearly 50 per cent. Some 950 vessels for various classes of service fall below the code standard of 4.21, but above the 2.86 value previously mentioned. They represent installations where engineers or authorities in charge were permitted to weigh the factors of safety that they would consider acceptable.

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for Fluids up to 350° F.

13

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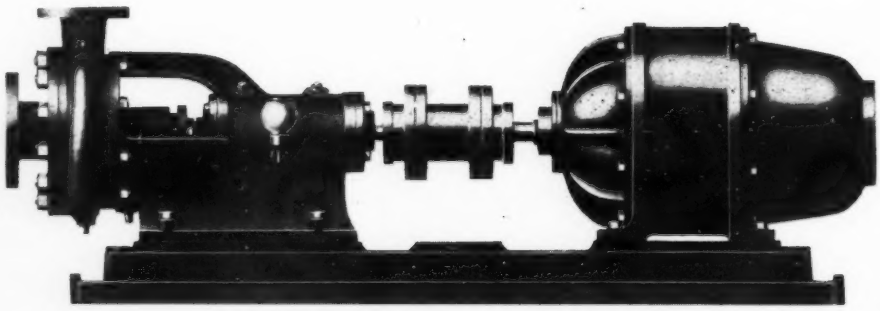

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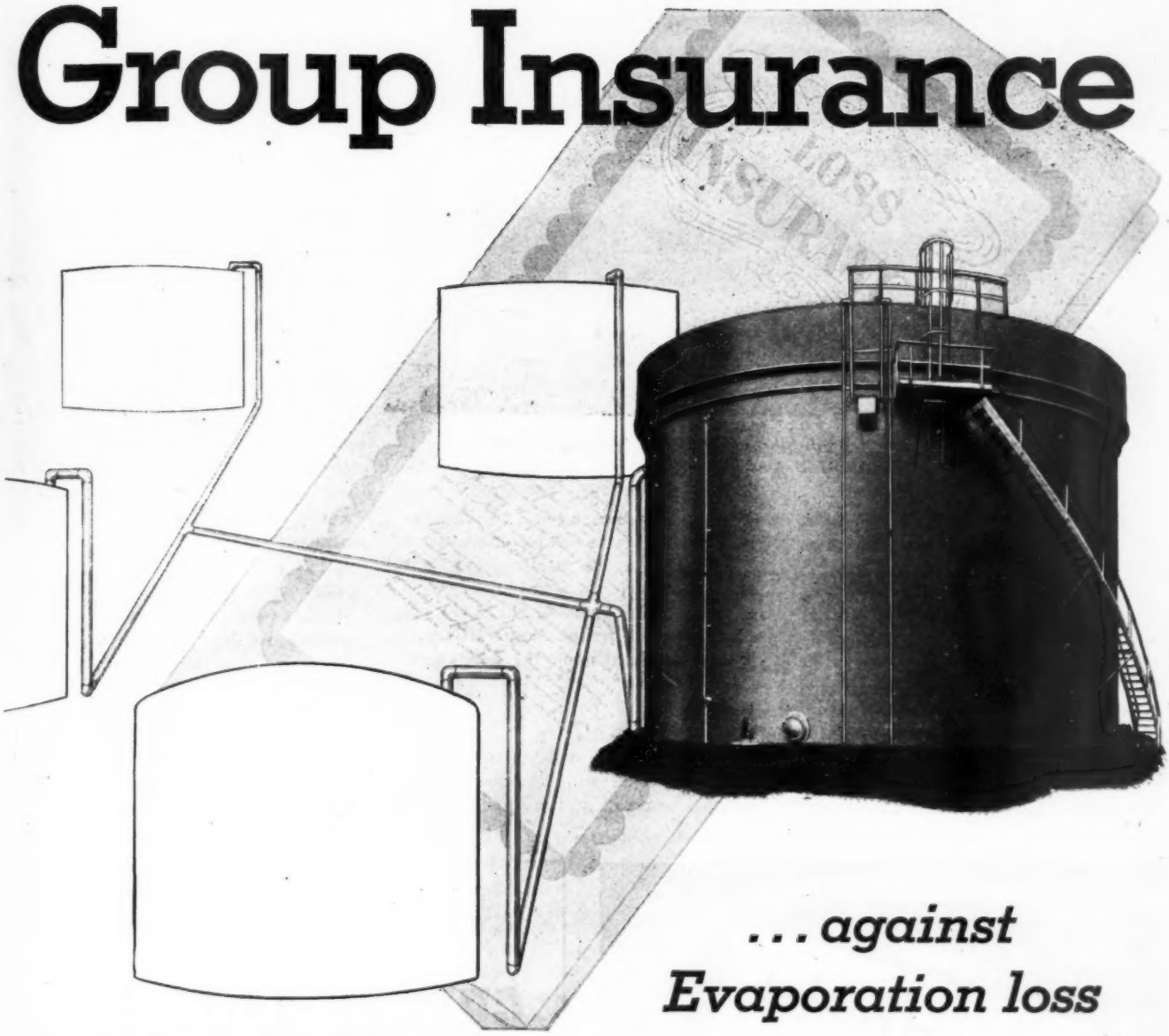

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Fig. 4. Partial shipment of multi-layer vessels for working pressure of 4500 lb. per sq. in.

Attention is now directed to curve C, which shows the factors of safety upon the yield point of the steel used. Stresses were again calculated by the Lamè formula. Due to the fact that the ratio of yield point to ultimate strength is greater than one-half for the steels used, but varies somewhat between steels, the curve does not parallel curve A. It does, however, consistently lie above a factor of safety of 2.11. The large group represented by the right-hand portion of the curve has a factor of safety on the yield point of the steel of 2.14. This particular steel has a yield point equal to 75 per cent of its minimum ultimate tensile strength.

As mentioned above, the stress calculations used for the comparative purposes were based upon the well known Lamè formula:

$$S = P\frac{(R_0^2 + R_L^2)}{R_0^2 - R_L^2}$$

in which S is the unit hoop stress at the inner surface in lb. per sq. in., P is the internal working pressure in lb. per sq. in., and R_0 and R_L are the radii of the outside and inside of the cylindrical shell in inches. This formula or a modification of it has generally been accepted by the codes for thick walled vessels. Strictly speaking, the Lamè formula applies only within the elastic range of the material. The formula as given above is for the specialized case for internal pressure only and for stress at the inner surface. For internal pressure only, the hoop stress at the outer surface is less than that at the inner surface by an amount equal to the imposed pressure and the hoop stress in the vessel wall varies with the radius, but not in direct proportion. For any thick walled vessel, either solid or layer, there is, therefore, an inefficient use of the steel in the outer portion of the shell if there is no initial prestressed condition to compensate for the unequal stresses set up under load.

The total load to be carried by the vessel wall must be equal to the internal pressure multiplied by the radius. If this loading can be carried by stresses that are approximately equal throughout the vessel wall, the most efficient use is being made of the load carrying medium. This equalization of stress is possible if an initial prestressed condition of the vessel wall can be obtained in which the inner wall is in compression, the outer

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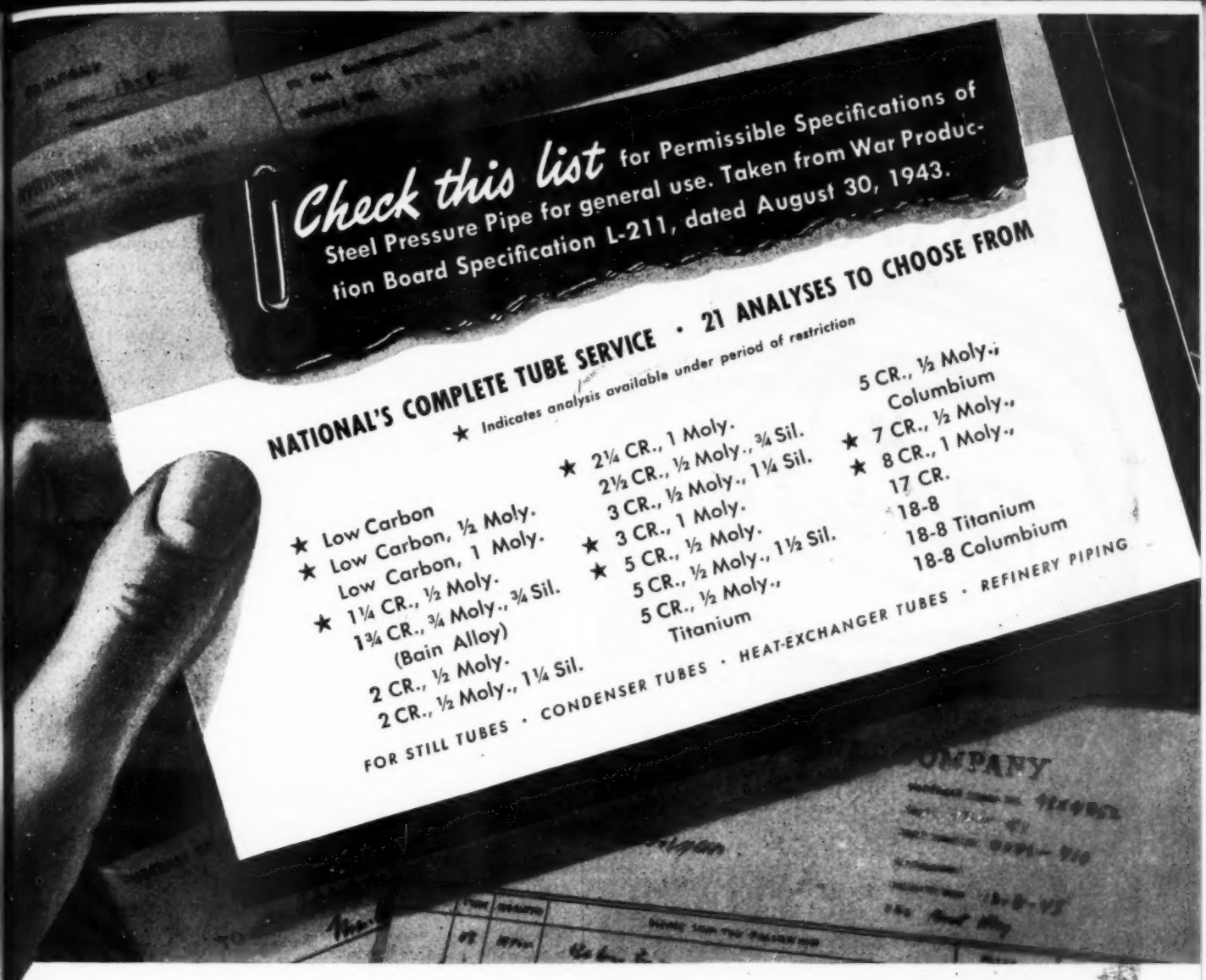
Check this list for Permissible Specifications of
Steel Pressure Pipe for general use. Taken from War Production Board Specification L-211, dated August 30, 1943.
NATIONAL'S COMPLETE TUBE SERVICE • 21 ANALYSES TO CHOOSE FROM
★ Indicates analysis available under period of restriction
★ Low Carbon
★ Low Carbon, ½ Moly.
Low Carbon, 1 Moly.
★ 1¼ CR., ½ Moly.
1¾ CR., ¾ Moly., ¾ Sil.
(Bain Alloy)
2 CR., ½ Moly.
2 CR., ½ Moly., 1¼ Sil.
★ 2¼ CR., 1 Moly.
2½ CR., ½ Moly., ¾ Sil.
3 CR., ½ Moly., 1¼ Sil.
★ 3 CR., 1 Moly.
★ 5 CR., ½ Moly.
5 CR., ½ Moly., 1½ Sil.
5 CR., ½ Moly., Titanium
5 CR., ½ Moly., Columbium
★ 7 CR., ½ Moly.,
★ 8 CR., 1 Moly.,
17 CR.
18-8
18-8 Titanium
18-8 Columbium
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How to get available seamless pipe and tubes *quicker*

IN spite of the fact that War Production Boards' Limitation Order L-211 to save valuable alloy elements such as chrome and nickel has been distributed for some time, frequent requests come in for alloy steel pipe and tubing that are restricted. This list will help you eliminate waste motion and expedite deliveries. Keep it handy. If you need technical help to determine which available alloy will best fit your conditions, call in the NATIONAL Tube specialist. He knows which alloys are suitable for each application.

As a matter of engineering information, we are listing NATIONAL's "Complete Tube Service"—21 analyses of alloy steel tubes. However, the red stars designate the only ones available at the present time. When some special operating conditions are such that certain non-standard alloy tubes are required, special permission can be secured from the WPB for the use of such material.

Before you order pressure pipe or tubing for refinery use, be sure to look over this list. You can save days—possibly weeks—in unnecessary correspondence.

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portion is in tension, and the stress varies throughout the wall so that when the Lamè stress distribution due to working pressure is superimposed upon the prestress, the net result is a uniform stress distribution. Theoretically, the prestress range from compression on the inside to tension on the outside should be not less than the working pressure.

The structural nature of a layer shell combined with the method of fabrication used automatically provides a close approximation of the desired stress distribution. A thin inner shell is first formed and welded after which successive thin layers of steel are wrapped upon the shell, each layer being pulled into tight contact with the existing shell and then welded. The combination of the wrapping load imposed plus the weld shrinkage tends to produce a compression in the portion of the shell fabricated and a tension in the outermost layer. As the shell is constructed, a desirable condition of prestress is produced in which compression equal to or in excess of the working pressure obtained. The final pressure test to twice the working pressure tends to modify the stress distribution toward the desired values.

Circumferential stress-strain readings have been taken upon the interior of several multi-layer cylinders in the course of the wrapping operation and all show a progressively increasing compression upon the inner shell. Fig. 2 shows the progressive increase gained in one instance where measurements were obtained. Fig. 3 shows the ends of two layer shells. At the right is a shell after the wrapping has been completed. The locations of the staggered longitudinal seams are evident. In the view at the left there appears the end surface of a similar cylinder after scarfing. It should be noted that it has the appearance of having been made from a solid piece of steel.

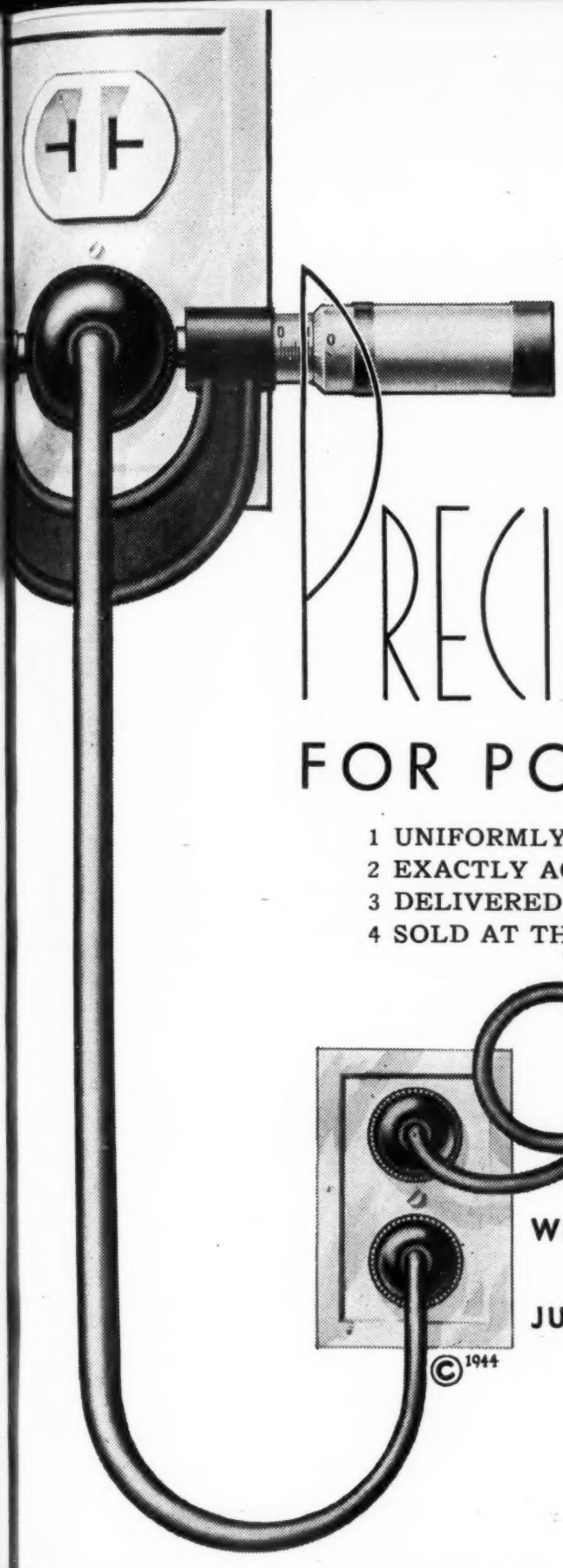
When manufactured as described above, the prestress produced in fabrication reduces the working stress at the inner surface and increases that at the outer surface. Under conditions of working load, a uniform stress through the wall means a reduction of the otherwise high inner surface stress and an increase in the factor of safety or the thickness of the vessel wall may be decreased with the original factor of safety maintained. Curve B in Fig. 1 gives the factor of safety upon the yield point of the steel when calculated for uniform wall stress. Under such conditions, the Lamè formula is resolved into the simple formula:

$$S = \frac{PR}{t},$$

which was used for curve B and in which S is the working stress in lb. per sq. in., P is the internal pressure in lb. per sq. in., and R and t represent the inside radius and wall thickness, respectively, in inches. The actual factor of safety upon the vessels built was, therefore, considerably above that computed for a non-prestressed condition as was assumed when using the Lamè formula for the calculation of the values shown in curve C. The increase in factor of safety or the possible relative decrease of wall thickness will be more marked as the diameter to thickness ratio decreases for any vessels considered.

The corrosive service to which some high pressure vessels are subjected makes it necessary that all exposed metal surfaces be of some alloy to minimize the destruction of the material used. Where heavy forgings are involved, this necessitates the use of the required alloy for the entire wall thickness, which entails a waste of critical materials. In the construction of a multi-layer vessel, the inner shell may be made of solid alloy or may have a thin spot welded or clad surfacing of alloy to provide the desired protection. The conservation of essential metals under such conditions becomes very evident. The load-carrying portion of the shell may be made from any weldable steel that has the desired physical properties.

Being made from readily weldable steels, the multi-layer shell automatically adapts itself to field assembly where transportation conditions preclude or make extremely difficult the



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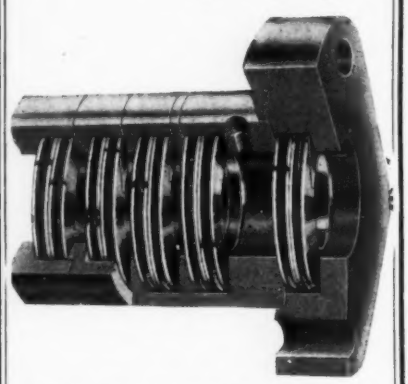

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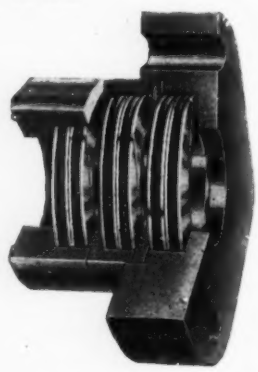

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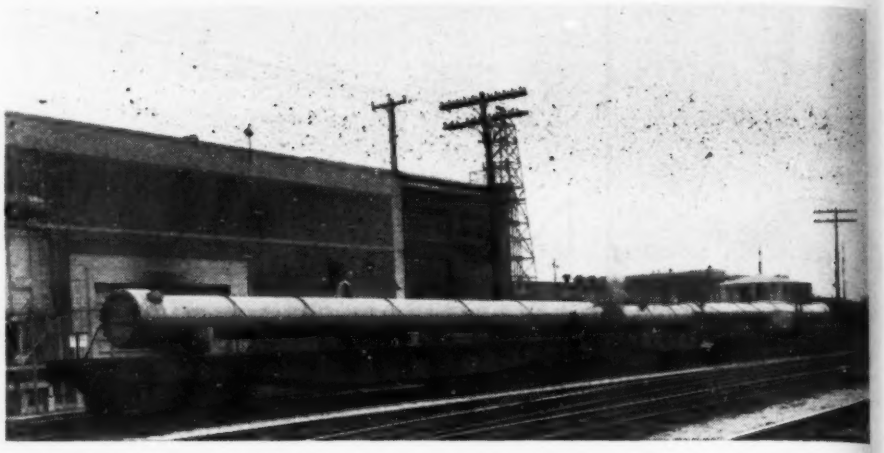


Fig. 5. Shipment of multi-layer vessels for a chemical process plant. Working pressure, 2000 lb. per sq. in.

movement of complete vessels. The welding of the deep circumferential seams, although requiring a certain technique, does not prevent the making of an excellent job in the field without the necessity of stress relief by heating.

The services to which layer vessels may be applied are numerous. As compressed air tanks, they serve as starting tanks for diesel engines and for accumulator systems. Closely allied with this type of vessel are large storage cylinders for such gases as oxygen, hydrogen, helium, and carbon dioxide. In the chemical field they serve in the production of synthetic ammonia and numerous other processes connected with the manufacture of dyes and explosives. They have been used as hydraulic gate cylinders and are now in service in the oil fields for repressuring purposes.

Regarding the working pressures to which they are adaptable, the range thus far has been up to 5250 lb. per sq. in. with no evidence that this is approaching a limit. The accumulators and gas containers are principally in the range from 2000 to 4500 lb. per sq. in. and the chemical vessels in the 3000 to 5000 lb. per sq. in range. Repressuring service so far has called for vessels of diameters up to 60 in. with pressures of the order of 2000 to 3000 lb. per sq. in.

Up to the present time, the maximum wall thickness has been 8½ in. A considerable number of the chemical and accumulator vessels have walls about 6 in. thick. Small light vessels for special service at 3000 and 3500 lb. per sq. in. pressures have been built, having wall thicknesses somewhat less than the above values. The lower limits would be set by the cost after giving due consideration to such special features as the multi-layer construction can supply to better advantage than the solid wall.

To show the importance of design, a tabulation is included showing the saving in weight of the 5451 vessels covered by Fig. 1 had all of them been designed and built upon the basis of the proposed factor of safety of 4 and 95 per cent welding efficiency with the wall thickness calculated using the simple formula:

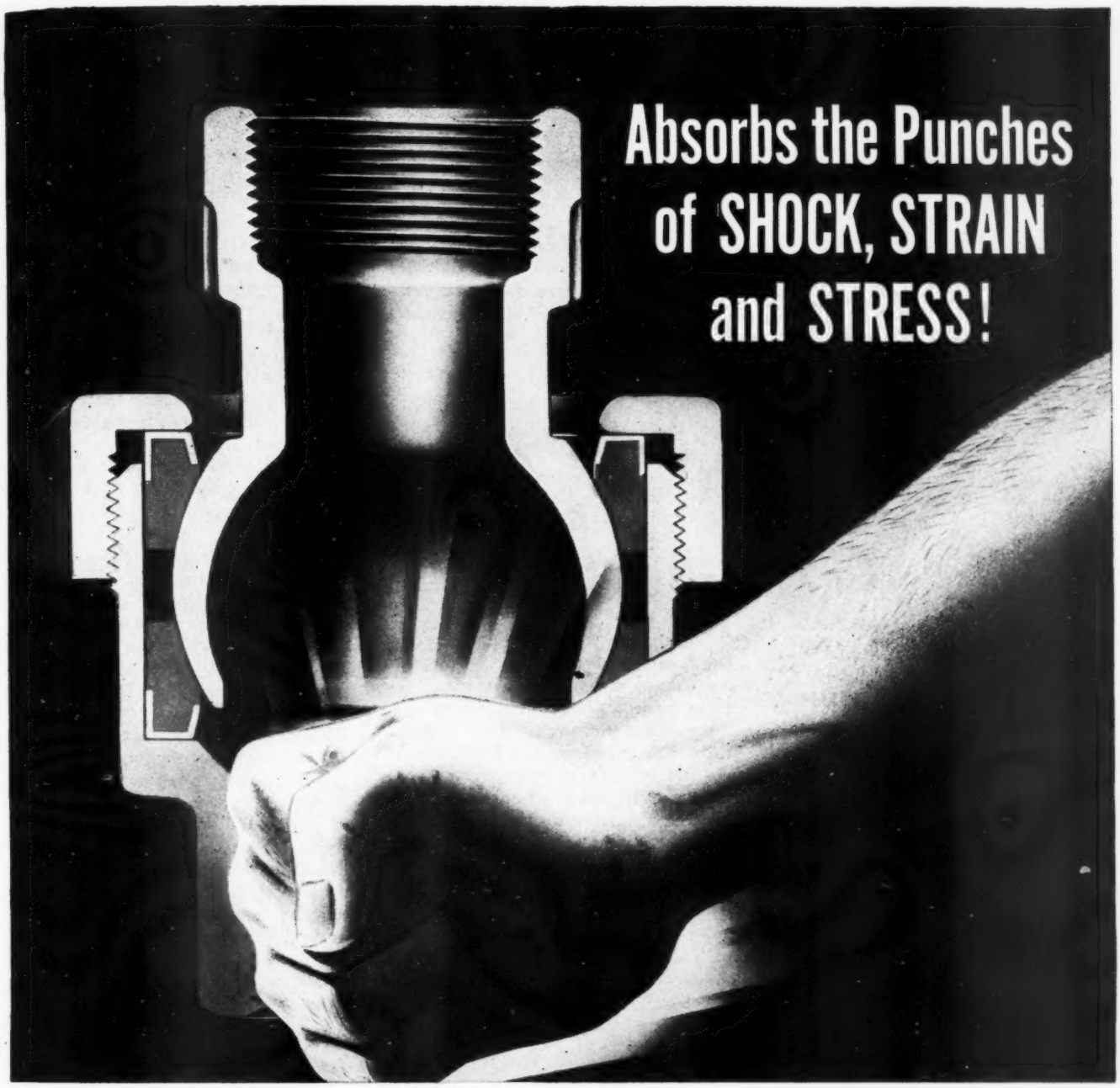
$$t = \frac{PR}{S}$$

The saving in weight shown is the difference between the weight of the vessels as built compared to the weight had they been designed on the proposed basis. In preparing the tabulation, the weight of only the parts affected has been considered. The savings for the early years should not be considered, strictly speaking, because during that period the construction was still under development and was gaining recognition. This, however, is certainly not true for the last 5 or 6 years.

POSSIBLE SAVINGS IN WEIGHT BY YEARS FOR MULTI-LAYER VESSELS BUILT

Year	*Saving, pounds*
1931	646
1933	23,784
1934	1,748
1936	11,880
1937	37,258
1938	96,683
1939	295,187
1940	2,471,208
1941	1,793,488
1942	6,048,111
1943	967,353
TOTAL	11,747,346

The tabulation given makes evident the savings in critical steel plate that might have been effected had industry been able to take full advantage in all cases of the construction and design described. Lest the figures given be considered excessive, the following three concrete examples may better indicate what could have been accomplished for specific cases.



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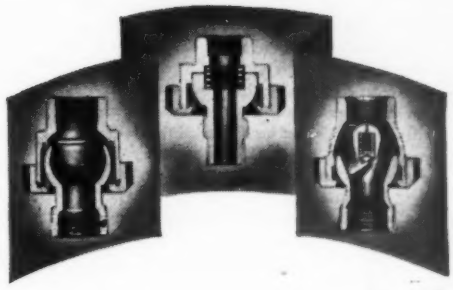

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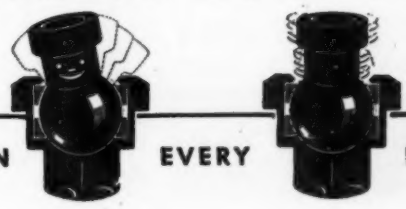

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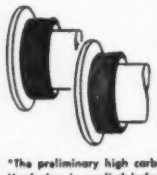
ABOVE are two reclaimed rollers taken from the same tractor. The upper roller was rebuilt to size with high carbon electrodes alone, but the lower roller carried a protective layer of Stoody Self-Hardening over the high carbon build-up*.

Abrasive conditions encountered in tractor operation were so severe the top roller was worn out in three months' time. The Stoody Self-Hardening, however, kept the lower roller in operation for another three-months period, a life increase of 100%!

Cost of the Stoody Self-Hardening deposit can be ignored, considering benefits obtained and the time saved in eliminating an extra overhaul.

Hard-facing can be applied either of two ways: (1) A bead run around the outer edge and space between the bead and collar filled in with horizontal welds or (2) A bead around the outer edge to bring the roller back to diameter, and intervening area between outer edge and collar filled with a continuous spiral of hard metal. Either method is equally successful but the latter has the advantage of more easily maintaining roller concentricity.



Have you received your copy of Stoody Specification Sheets? They illustrate and describe dozens of equipment-saving applications thru the use of hard-facing—sent free on request.

*The preliminary high carbon build-up can be eliminated if Stoody Self-Hardening is applied before excessive wear has occurred on the roller.

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STOODY HARD-FACING ALLOYS
Stop wear . . . Eliminate Repair

A large number of vessels were required on one of the critical defense projects for operation under pressures ranging from 3000 to 5000 lb. per sq. in. Fig. 4 shows 4 of these vessels loaded for shipment. Most of them were for installation in code states and it was decided to base the design upon the then prevailing code factor of safety of 5 with a joint efficiency of 90 per cent. Had these vessels been designed upon the basis proposed above, it would have meant a saving of steel during the critical years of 1939 to 1942 amounting to the following:

	Vessels	*Saving, pounds*
1939 . . .	5	113,900
1940 . . .	64	1,469,750
1941 . . .	27	375,520
1942 . . .	8	132,630
	104 Total	2,091,800

Even at 10 cents per lb. for the weight saved, this would amount to $209,180.

During the years 1941 and 1942, a large number of vessels were required in connection with another critical defense project. These vessels were also designed for working pressures of 3000 to 5000 lb. per sq. in. Fig. 5 illustrates a portion of these vessels prepared for shipment. In one plant, of the 4 or 5 for which these vessels were built in the critical year of 1942, the saving in steel for the 60 vessels required would have been about 800,750 lb. had the proposed basis been used.

In connection with the high octane gasoline program, large high pressure vessels have been furnished during the last 2 or 3 years for working pressures ranging from 1500 to 2000 lb. per sq. in. (Fig. 6). Here again, in order to comply with existing code factors of safety, the vessels were designed much heavier than would have been required had the benefits of prestress been recognized.

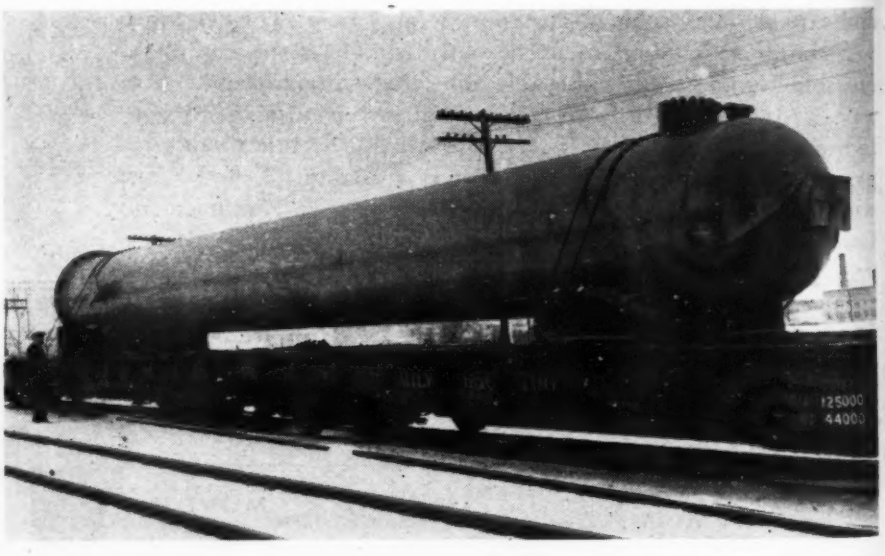
In 1942, twenty vessels on two of these projects utilized 366,000 lb. of critical steel plate in excess of what would have been required.

In 1943, eight vessels on another repressuring project required 218,000 lb. of excess material due to compliance with current codes. In the case of these vessels, the excess weight not only resulted in the use of excess critical material, but also involved considerable additional labor and expense both for fabrication and for transportation of the very heavy weights across country where roads and special handling facilities had to be provided. This also caused delay in getting plants into operation.

These figures testify to the importance to industry, and in times of emergency to national defense, of being able to utilize economies and materials possible with new methods of design and construction. In the case cited, it will be noted that the multi-layer construction has a service record of about 10 years and this without any failures, yet it has been considered necessary in many applications to satisfy local regulations and adopt factors of safety or methods of design that required an excess weight of about 6000 tons of steel plate during the last 5 years, over and above what should have been necessary. Under a similar system of regulations and restrictive practices, the world's great bridges could never have been built, large transcontinental gas pipe lines would be impractical, and the modern airplane would still be a dream.

☆ ☆ ☆

Fig. 6. Multi-layer vessel for oil field service; less than 1900 lb. per sq. in. pressure; total weight, 185,000 lb.



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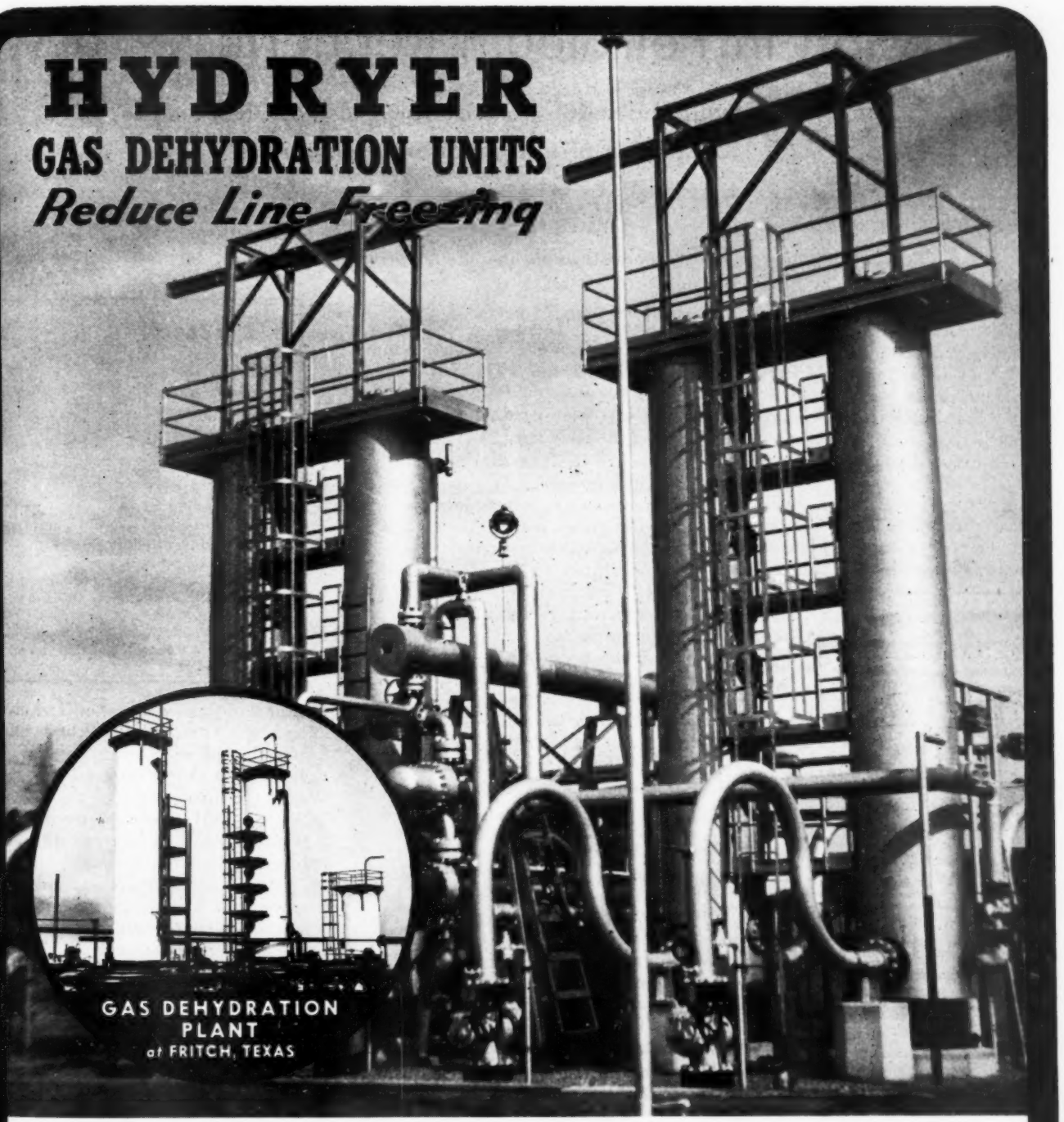

PASSAGE of natural gas through a solid adsorbent in the Pritchard Hydryer Unit removes water vapors which cause "pipeline ice" and line freezing. Unit above is capable of drying 100,000,000 cu. ft. daily at pressures of 1,000 p.s.i. Designed and constructed by J. F. Pritchard Company, *Natural Gas Division*, Fidelity Building, Kansas City, Missouri.

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Corrosion in Petroleum Refineries

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☆ Data and suggestions of value to those responsible for solution of this important problem

by B. B. Morton

Development and Research Division, The International Nickel Company, Inc.

REFINERY corrosion is a most complex subject. One is tempted to derive general rules from its study and is continually thwarted by the next set of test results.

One broad rule that does appear to have emerged from considerable study is that the character of the corrosion changes with the presence or absence of liquid water. This is the equivalent of saying that above some temperature level one type of corrosion is to be expected and below this level another type.

TABLE 1

Corrosion results from a bubble tower

Location	Bottom of tower	Top of tower
Temperature, °F.	700° F. (approx.)	185° F.
Metals	**Corrosion rate**	**Penetration, in. per yr.**
Mild steel	0.033	0.091
18 chrome 8 nickel	0.00006	0.029
Monel	0.200	0.014
Inconel (80 nickel 13 chrome)	0.00015	0.035
18-8-3 moly	0.00003	0.025

Note: Injection of a base reduced corrosion rate at top of tower.

TABLE 2

Effects of chromium content on resistance to sulphuric attack

Temperature, °F.—650-700° F.
Operation—gas oil—cracking

Alloy	Penetration, in. per yr.
1 9% chrome—20% nickel	0.00130
2 14% chrome—80% nickel	0.00036
3 18% chrome— 8% nickel	0.00002

Steel severely attacked in same environment.

Note: The attack on any of the alloys above insignificant under the conditions of test.

Beyond this, few general rules seem to apply.

As an example, consider a bubble tower in operation. The feed is coming in at, say 600-700°F.; the top is cooled by the return of reflux. The results are noted in Table 1.

From a study of data along the lines of those in Table I, one must conclude that, above a certain temperature level, sulphur attack is the chief cause of destruction and below this level different chemicals are attacking the metals. It will be further noted (Table 2) that the resistance of the alloys in the high temperature region is in proportion to their chromium contents. Dixon* and others have pointed out that the ability of chromium to resist sulphur at elevated temperatures is most pronounced in the first additions of this element to a steel base. The widely used 4-6 per cent chromium steels are a result of this observation. The sulphur corrosion resistance is progressively improved with additions up to about 20 per cent chromium. Molybdenum is added to the alloys containing up to about 10 per cent chromium to prevent temper brittleness. Nickel, associated with chromium in alloys of the austenitic nonmagnetic group, enhances the corrosion resistance of the high chromium alloys and improves the load-carrying properties at elevated temperatures.

For the lower temperature regions, where liquid water can exist, the chromium-containing alloys lose some of their importance and non-ferrous alloys, such as nickel, monel, brass, bronze and the special alloys, Hastelloy, LaBour, Worthite, Pioneer Metal, and others, are indicated.

*E. S. Dixon, metallurgist, The Texas Company.

TABLE 3

Approximate compositions

Material	Nickel, per cent	Copper, per cent	Iron, per cent	Chromium, per cent	Molybdenum, per cent	Aluminum, per cent	Silicon, per cent	Manganese, per cent	Tungsten, per cent	Carbon, per cent
Nickel	99.4 (a)	0.1	0.15	....	....	....	0.05	0.2	....	0.1
Monel	67.	30.	1.4	....	....	....	0.1	1.	....	0.15
"H" Monel (b)	65.	29.5	1.5	....	....	....	3.	0.9	....	0.1
"S" Monel (b)	63.	30.	2.	....	....	....	4.	0.9	....	0.1
"K" Monel	66.	29.	0.9	....	....	2.75	0.25	0.4	....	0.15
Inconel	79.5	0.2	6.5	13.	....	....	0.25	0.25	....	0.08
Hastelloy A	53.	....	22.	....	22.	....	1.	2.	....	....
Hastelloy B	60.	....	6.	....	32.	....	1.	1.	....	....
Hastelloy C (b)	51.	....	6.	17.	19.	....	1.	1.	5.	....
Hastelloy D (b)	85.	3.	....	....	....	1.	10.	1.	....	....
Illium G (b)	60.	4.	6.	21.	6.	....	1.	1.	1.	....
Illium R	60.	3.	8.	21.	5.	....	1.	1.	1.	....
LaBour (b)	53.	5.0	8.0	23.	4.0	....	4.0	0.5	2.0	....
Duramet T	22.	1.0	bal.	19.	3.5	....	....	....	....	0.07
Worthite	24.	1.7	bal.	20.	3.0	....	3.3	0.6	....	0.07

a–Including Cobalt. b–Only as castings.

B. B. MORTON was an officer in the first World War and served with the army of occupation —In 1921 entered Virginia Polytechnic Institute, majoring in metallurgy— After graduation worked for American Smelting and Refining Company in Mexico, Bethlehem Steel Company, Standard Oil Development Company—Is now in development and research division of The International Nickel Company—Is member of A.S.M.E., A.P.I., and A.S.M.

Table 3 gives some approximate compositions of a number of the alloys mentioned above.

Within recent years the interest of refineries in high octane gasoline and in specialities for the war effort, has led to the use of many reagents that are corrosive to carbon steel and other basic materials of refineries. Some mention of these reagents and their associated material follows.

Sulphur

Hydrogen sulphide is the form in which sulphur is most prone to attack steel and other materials. At temperatures above 500°F. alloys containing increasing amounts of chromium are required to resist attack. This has been discussed previously.

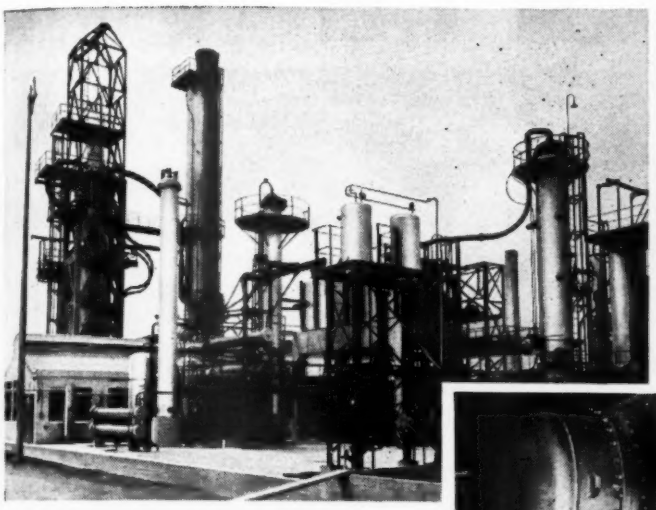
At lower temperatures, and especially where water can exist, monel, brass, and bronze are resistant to attack by the weak acids formed.

Sulphur in the form of sulphur dioxide can form a very corrosive solution in water. Type 316 stainless steel (18 per cent chromium, 8 per cent nickel, and 3 per cent molybdenum) is apparently quite resistant to this solution.

Sulphuric Acid

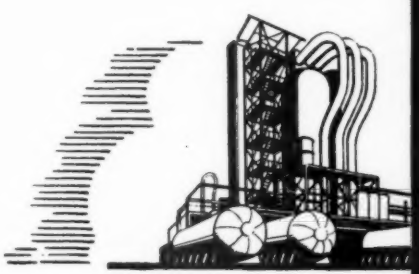
Sulphuric acid has always played a prominent part in petroleum refining.

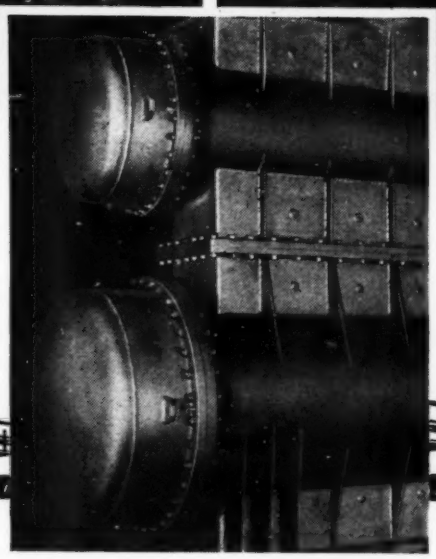
How Chromium Steels
help to speed refinery production

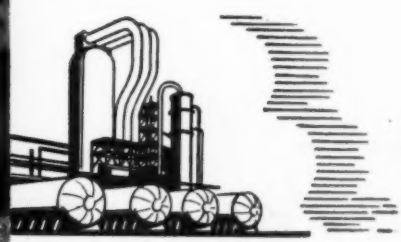


Cracking still tubes of 18-8 chromium-nickel stainless steel withstand high temperatures and pressures.

Vessels lined with 12 per cent chromium steel withstand corrosion, and save weight.







The 4 to 6 per cent chromium steels containing a small amount of molybdenum are being used for heat exchanger tubes and condenser pipe.

● Chromium steels are resistant to corrosion, abrasion and oxidation and have high strength even at elevated temperatures. Because of this combination of properties, the use of chromium steels in oil refinery equipment keeps costly and time-consuming shutdowns for repair and replacement at a minimum and makes for fast, uninterrupted, economical operation.

The 4 to 6 per cent chromium steels are used for tubes, pump bodies, and transfer lines; the 12 to 14 per cent chromium steels for reaction chamber liners, pump parts, and valves; the 18-8 chromium-nickel stainless steels for furnace tubes and distillation equipment, including trays, bubble caps, header boxes, and valves; and the 25-12 chromium-nickel steels for furnace parts, fractionating towers, and other applications where resistance to higher temperatures is involved. The illustrations show a few applications which may suggest where you can use chromium steels to speed up production of essential petroleum products.

We do not make steel of any kind, but we have for over 37 years produced Electromet ferro-alloys used in making steel. With the knowledge accumulated from this experience, we are in a position to give you impartial assistance in the selection of a chromium steel to suit your particular needs.

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TABLE 4

Corrosion of Hastelloy B in 45% H_2SO_4 at 250°F. (1725 r.p.m.)

C.P. sulphuric acid	0.033 in. per yr.
C.P. sulphuric acid plus 1.54 g.p.l. $CuSO_4$	1.339 in. per yr.

TABLE 5

Tests of three metals in fuming sulphuric acid

Temperature.....188° F. (±2° F.)
Time.....66½ hr.
Rotation.....16 ft./min. for 42 hr., quiet 24½ hr.

Metal	Penetration—in./yr.
1 24 chrome—12 nickel	0.008
2 25 chrome—20 nickel	0.009
3 Mild steel (S.A.E. 1020)	0.118

TABLE 6

Results of some studies of corrosion by naphthenic acids

Temperature.....550° F.
Location.....column of vacuum unit

Metal	Penetration, in. per yr.
Mild steel	0.0163
18 chrome— 8 nickel	0.0236
18 chrome— 8 nickel—3 moly	0.0002*
16 chrome—13 nickel—3 moly	0.0009*
Inconel (80 nickel—13 chrome)	0.0007*
Monel (69 nickel—20 copper)	0.0012
Nickel	0.0006
Ni-Resist (cast iron)	0.0109
Cast iron	0.0080

*Three applicable metals. Possible sulphur attack (above 500° F.) precludes monel or nickel. Monel in use at temperature below 500° F.

Lately its introduction as a catalyst has widened interest in materials of construction.

Lead has long been used to combat corrosion from the weaker concentrations of sulphuric acid and its use and limitations are fairly well known in refinery circles.

For high temperature uses, and especially with high concentrations of acid, the Hastelloy "A" and "D" alloys are used. The "D" form is especially resistant. The alloy is used to concentrate sulphuric and to handle hot acid in various concentrations. It is lacking in ductility, which somewhat limits its use. Hastelloy B is used in both wrought and cast form to handle hot, concentrated sulphuric and is preferred by some users over the other analyses.

As a sidelight on the effects of unpredicted reagents upon the course of corrosion, a case is cited in which Hastelloy B was handling hot sulphuric acid with satisfaction until the steam became contaminated with copper. The effects are shown in Table 4. The 40-fold increase in corrosion rate noted could hardly have been foretold.

Some time ago the laboratory of the International Nickel Company was asked to investigate the behavior of fuming sulphuric acid upon some materials. It was recognized that fuming sulphuric acid is oxidizing in nature so two high chromium alloys were studied in comparison with mild steel, which, due to a passivating action of the acid, is often used with fuming acid. The results are given in Table 5.

The Hastelloy type of material is used in connection with fuming sulphuric acid in refinery service. Grade "C" is apparently the most appropriate of the group. Other alloys with high resistance to oxidizing media would probably be as satisfactory. The resistance of monel to sulphuric acid is indicated in Fig. 1.

The most resistant of metallic materials to sulphuric acid is the high silicon (13 per cent silicon) cast iron, such as "Corrosion" and "Duriron." The intense brittleness of this material necessitates special design features for successful use.

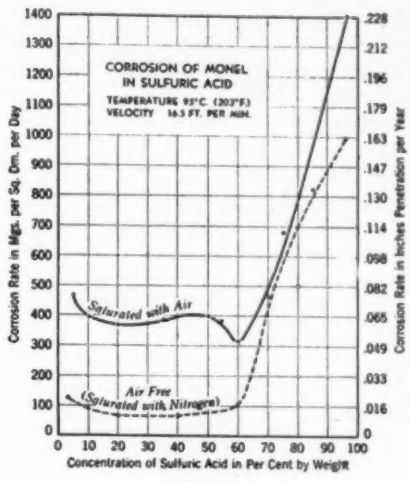


Fig. 1

Naphthenic Acid

Naphthenic acid, associated with many crudes, is quite corrosive at elevated temperatures. Some results of tests run under conditions conducive to attack by naphthenic acid are reported in Table 6.

The good behavior of monel is noted, but its use is not suggested at temperatures above 500°F. as sulphur attack will possibly occur. Monel is used commercially to resist naphthenic attack at temperatures below 500°F.

Inconel (80 per cent nickel - 13 per cent chromium) and 18 per cent chromium - 8 per cent nickel - 3 per cent molybdenum alloy are both highly resistant to naphthenic attack at elevated temperatures.

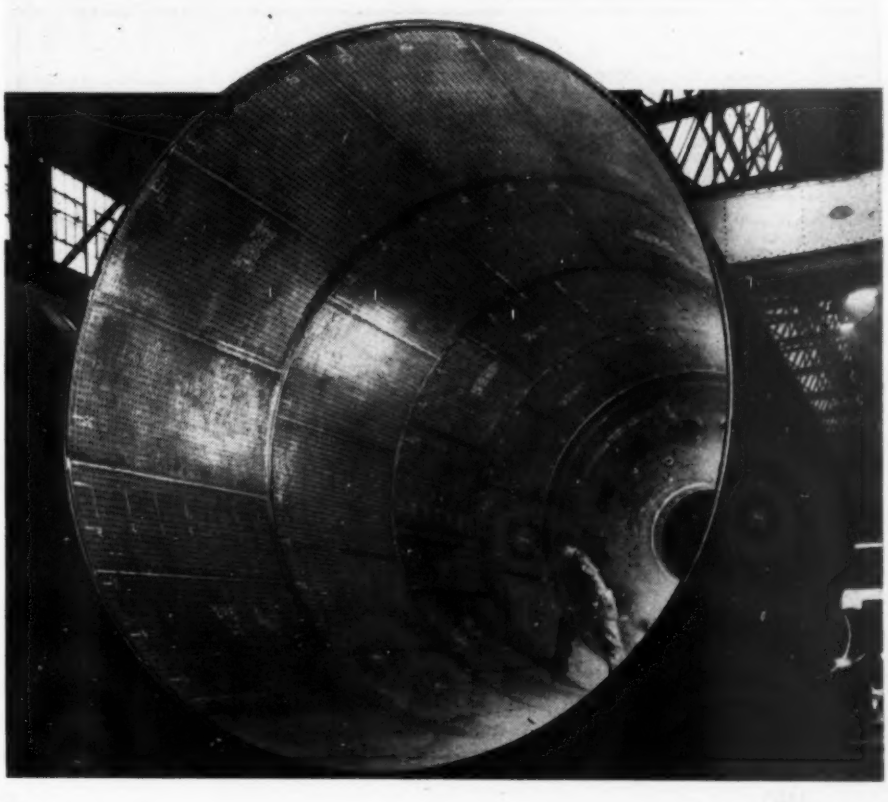
The surprise feature of the tests (Table 6) was the low resistance of the standard 18-8 stainless steel. This low resistance was amply checked and appears proved.

Hydrochloric Acid

Hydrochloric acid is one of the most corrosive reagents in refineries. It is often generated during cracking and topping operations from salts in the feed stock. It is used in the anhydrous form, as an atmosphere for an important reaction.

Hastelloy B is one of the most resist-

Fig. 2. Fractionating column lined with 18-8 stainless steel over large bottom section and with monel in top smaller diameter section. Tower 125 ft. long
(Photo courtesy A. O. Smith Corp.)

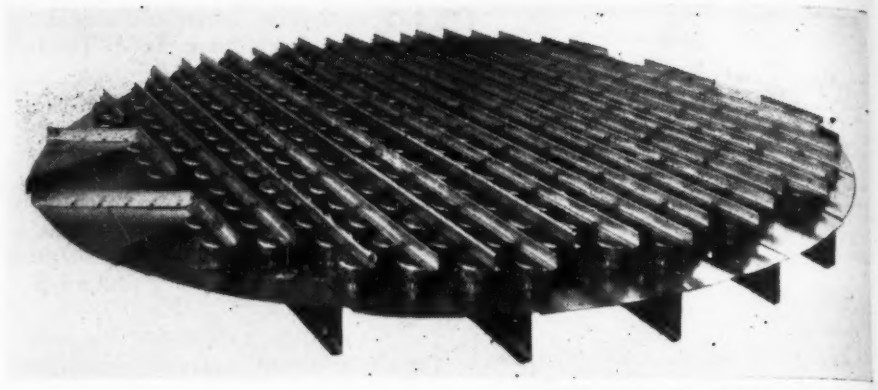


ant alloys to hydrochloric and is used as a liner and for parts of the equipment where a hydrochloric acid atmosphere prevails.

Nickel as a second, or possibly third, choice is also used. The order of choice being, Hastelloy B, Inconel, and nickel or monel. The location of Inconel in the order given is not soundly based on data from operating equipment. It is based on some laboratory studies.

The advent of HCL gas as an atmosphere into refinery operations came too suddenly to permit an exhaustive study of materials. The existing installations of Hastelloy B and nickel will have to be studied over a period of time in order to obtain a clear picture.

The ability of monel and nickel to resist the action of the hydrochloric acid generated during topping and cracking operations is well established; see Table 7. The most progressive practice is to use monel liners, (Figs. 2 and 3) and equipment in the cooler regions in the tops of towers and 18-8 or other stainless steels in the lower and hotter sections. The highest metal temperature to be used for monel is 500°F.



(Photo courtesy Fitz Glitsch & Sons.)

Fig. 3. Light weight construction tray and caps, fabricated from stainless steel or monel

Downcomer lines and shells of condensers are lined with monel with profitable results. For condenser shells of light weight, monel plate is used.

For reflux pumps, monel rods, shafts, valves, liners, and parts are used. Ni-Resist cast iron also finds wide application in reflux and product pumps as well as in valve and cock parts where resistance to hydrochloric acid is desired.

TABLE 7

Results of tests in top of bubble towers

Temperature	250° F.	Approx. 200° F.
Crude	West Texas	Michigan
Metal	Penetration rate, in. per yr.	
Mild steel	Destroyed	0.0500
5% nickel steel	Destroyed	.....
18% chrome—8% nickel.	Destroyed	0.0254
17 nickel—11 moly.—3 chrome	0.0527	.....
Monel (69 nickel—29 copper)	0.0031	0.0075
Nickel	0.0057	0.0069
Ni-Resist cast iron	0.0513	0.0131
Cast iron	0.1810	0.0430

Hydrofluoric Acid

Hydrofluoric acid is a fairly recent entrant into refinery usage. Intensive studies of the corrosiveness of this alloy have been carried out with the following results:

1. Silver is probably the most resistant metal so far tested. The effects of other corrosives present in petroleum products, e.g., sulphur, upon this metal remain to be evaluated.

2. Monel is possibly the most satisfactory commercial alloy for use with hydrofluoric acid in both the aqueous and anhydrous state, provided oxygen is absent. The effect of oxygen is shown in Table 8 in the section dealing with "Air-Saturated vs. Air-Free Tests."

3. Copper is very resistant to aqueous HF solutions but is vigorously attacked by anhydrous HF. Other elements in the oil may attack copper.

4. Steel is vigorously attacked at temperatures above about 150°F.

5. 70/30 copper nickel alloy has made a good showing in laboratory tests in both aqueous and anhydrous HF acid.

TABLE 8

Monel corrosion tests in hydrofluoric acid

Material	Acid conc., per cent	Temp., °F.	Agitator, gas	Time, days	Area* dm^2	Corrosion rates Mdd†	Corrosion rates Ipy‡
Air-free tests—Nitrogen agitation rate=100 cc/min.							
Monel (wrought) (approx. 69% nickel..... 29% copper,)	25	86	nitrogen	6	0.50	1.0	0.0002
	25	176	nitrogen	6	0.50	14.5	0.0024
	50	86	nitrogen	6	0.50	0.4	0.0001
	50	176	nitrogen	6	0.50	3.6	0.0006
Monel (cast)	25	86	nitrogen	6	0.13	3.5	0.0006
	25	176	nitrogen	6	0.13	8.3	0 0014
	50	86	nitrogen	6	0.13	2.8	0.0005
	50	176	nitrogen	6	0.13	13.5	0.0022
"S"-Monel (cast) (approx. 4% silicon)	25	86	nitrogen	6	0.30	1.5	0.0002
	25	176	nitrogen	6	0.30	1.1	0.0002
	50	86	nitrogen	6	0.30	2.3	0.0004
	50	176	nitrogen	6	0.30	12.1	0.0020
Air-saturated vs. air-free tests **Air agitation rate=300 cc/min. . . Nitrogen agitation rate=100 cc/min.**							
Monel (wrought)	25	86	air	1	0.50	230.0	0.0380
	25	86	nitrogen	6	0.50	1.0	0.0002
	25	176	air	1	0.50	67.0	0.0110
	25	176	nitrogen	6	0.50	14.5	0.0024
	50	86	air	1	0.50	48.7	0.0079
	50	86	nitrogen	6	0.50	0.4	0.0006
	50	176	air	1	0.50	241.0	0.0400
	50	176	nitrogen	6	0.50	3.6	0.0006

*dm^2=Square decimeter. †Mdd.=Milligrams per sq. decimeter per day. ‡Ipy.=inches penetration per year

Caustic

Caustic soda has long been used in refineries for various uses as washing of products, etc. Lately considerable interest has been shown in materials for units in which caustic is regenerated by a boiling action. Chief attack appears to take place upon the tubes of the heating unit.

Monel tubes have given a good account of themselves in this service and their use is steadily being extended. A 5 per cent nickel steel tube has been rather widely used. The results are erratic, ranging from poor to very good. Table 9 lists some results of tests involving a boiling caustic solution. Fig. 4 shows the installing of a monel lining in a vessel of a caustic regeneration unit.

Phosphoric Acid

Phosphoric acid has been used for some time in refineries as a catalyst. Some slight corrosion has been noted in lines subjected to condensation of steam used in the "blow-back" operation. Monel is used to line equipment subject to this corrosive condition.

Monel, Hastelloy C, and the 18 per cent chromium - 8 per cent nickel - 3 per cent molybdenum alloy all possess very good resistance to phosphoric acid in concentrations up to 35 per cent at elevated temperatures. Apparently concentration, temperature, and the presence of other materials affect the corrosion rate so markedly that a general

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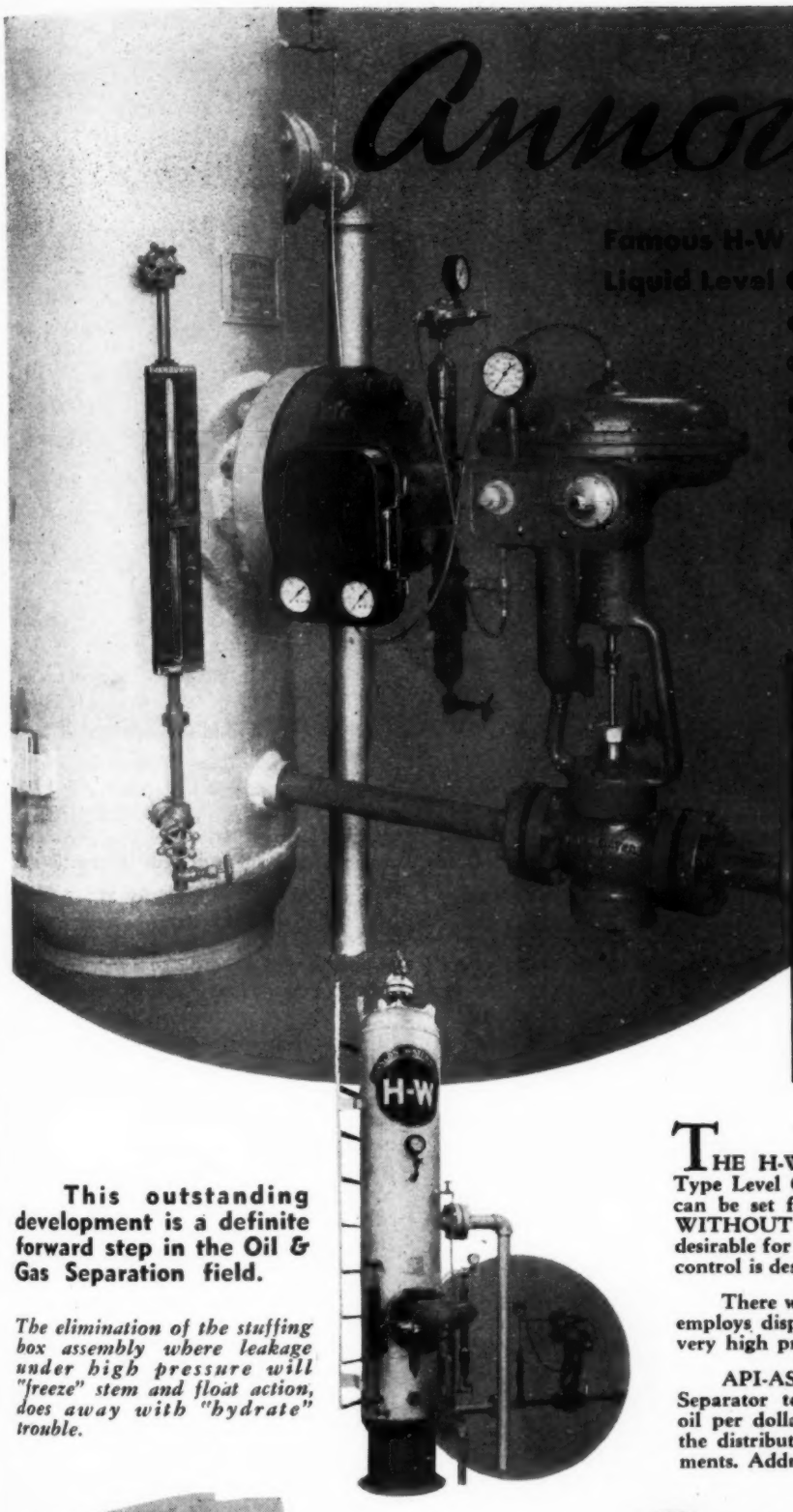

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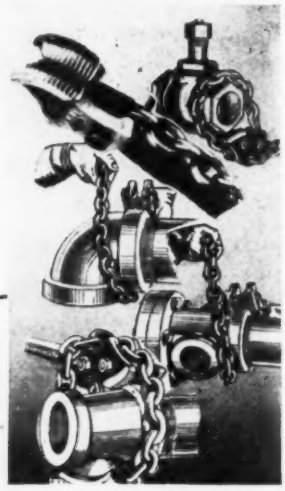

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(Photo courtesy Black, Sivalls & Bryson.)

Fig. 4. Lining tower of caustic regeneration unit with monel

statement covering uses with high concentrations and temperature cannot be made.

Solvents

The chlorinated solvents often break down to form a corrosive reagent. Monel is highly resistant to this reagent and also tends to prevent the breakdown. Monel is widely used to contact carbon tetrachloride in various industries.

Phenolic compounds, especially when contaminated with sulphur, rapidly attack carbon steel. The 18-8 stainless is used as liners and tubes to contact phenolic compounds and hydrocarbons at elevated (above 500°F.) temperatures. Monel is highly resistant to the phenol group of solvents and to furfural, which is also extensively used in petroleum refining. Vessels clad with monel, and in one case sprayed with monel, are used to store furfural.

General

Much could be written about the various types of corrosion, both galvanic and cell effects, but space does not permit.

On the oil side conditions are rarely very favorable to galvanic effects due to dissimilar materials. Oxygen is absent, and rarely does a suitable disposition of electrolyte exist. Except under unusual conditions of acid concentration, the absence of oxygen is very important in suppressing galvanic effects. The necessary conditions of flow often exist to aid concentration cell corrosion but the inhibiting effects of petroleum products and poor distribution of electrolyte serve to suppress this annoying type of corrosion. (In this corrosion, the washing away of ions of metal in solution from one point causes increased corrosion at the point by the vain effort of the metal to equalize concentration of ions in the adjacent liquid. Presence of dissimiliar metals is not an essential factor for this type of corrosion).

On the water side of condensing equipment all of the effects of oxygen, dissimilar metals, and conditions of flow favoring cell attack are present. The scope of this feature of corrosion is beyond the space of this article.

When oxidation is a factor the 18-8 alloys are suggested and are used as pump parts, etc. Monel, brass, and bronzes also give good service on the water side of equipment. Cast iron, due to its graphitic type of corrosive product, is used with success on the water side. This material can give galvanic protection to other metal without grievous harm to itself. Monel bolts in contact with cast-iron flanges in a salt water coolerant are reported in excellent condition after 20 years' service. Galvanic protection must have been a large feature here.

TABLE 9
Results of tests in boiling caustic solution (approx. 2% NaOH)

Temperature ..... 250° F.

Metal	Penetration, in. per yr.
Mild steel	0.0200
Monel	0.0014
70/30 copper-nickel	0.0250
5% nickel steel	0.0038
Ni-Resist cast iron	0.0230
Cast iron	0.0170

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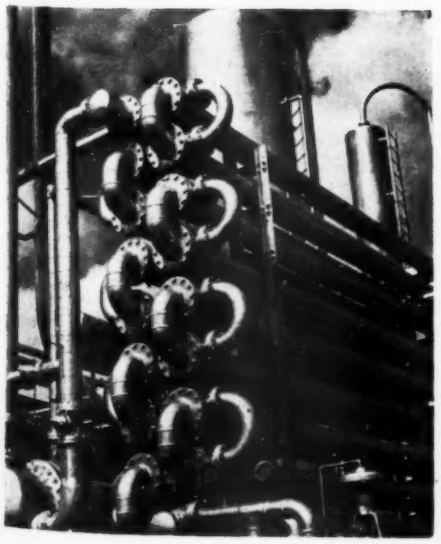

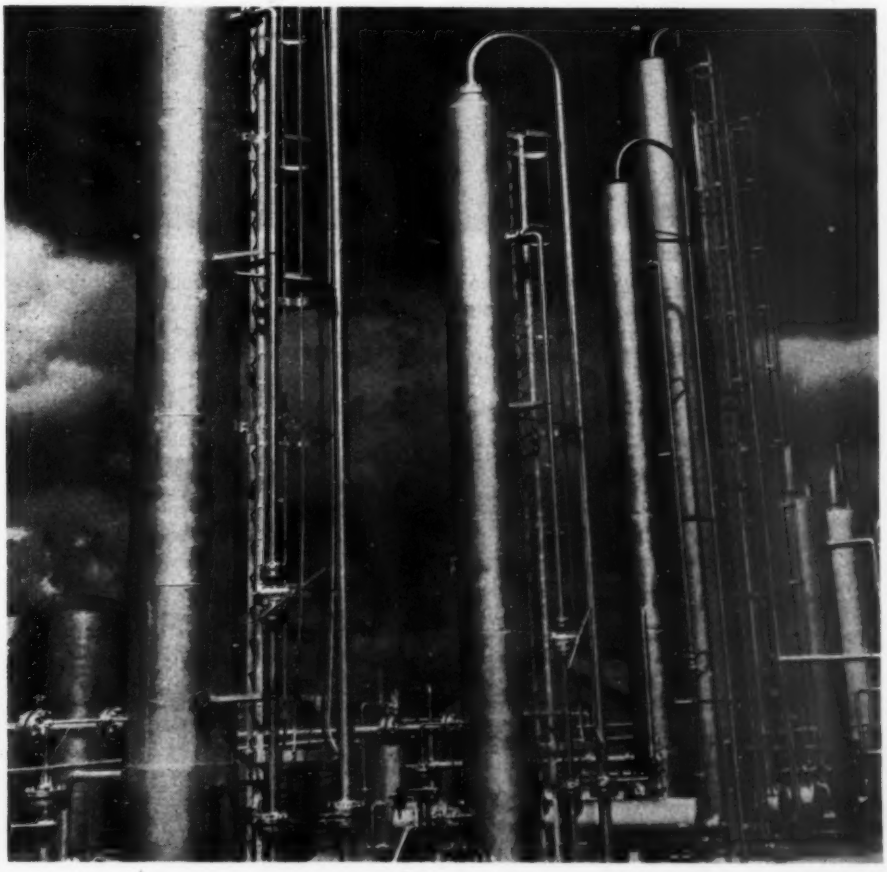

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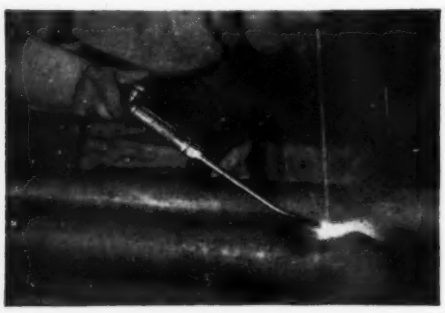
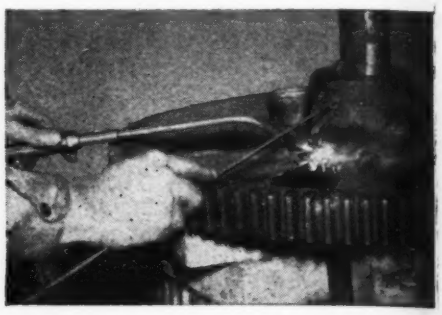
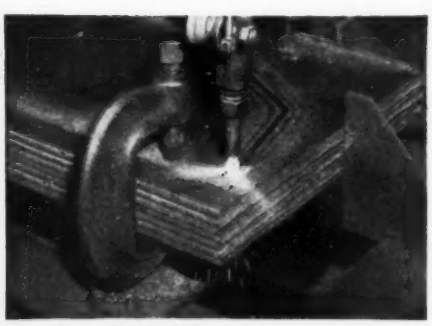




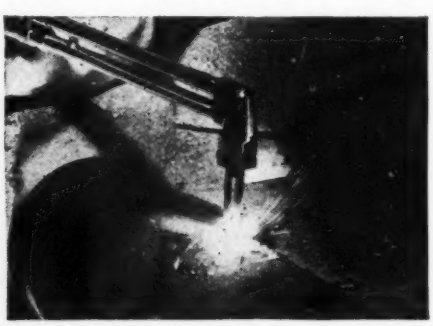
OXY-ACETYLENE WELDING

The oxy-acetylene flame makes possible the joining of practically any metals—like or unlike—so that the weld is as strong as the base metal itself. *Welded piping systems* in plants and refineries use less fittings, occupy less space, and remain leakproof indefinitely. Overland *pipe line welding* by Linde's steel-welding process produces strong, ductile welds in pipe of any size. *Bronze-welding* and resurfacing speed the repair of worn or broken parts and hard-facing with Stellite alloys makes parts subjected to abrasion, heat, or corrosion last from two to twenty-five times longer.



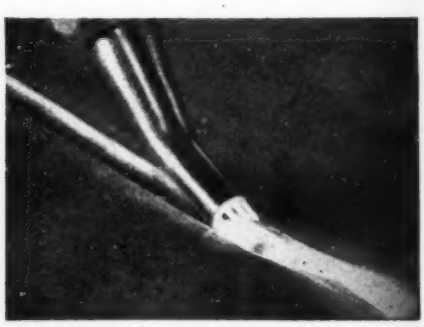
Machine Flame-Cutting

Shape-cutting with Oxweld machines quickly produces simple or intricate steel shapes with clean-cut edges that usually require no machining. This method permits the rapid production of identical parts from tightly clamped piles of plate.



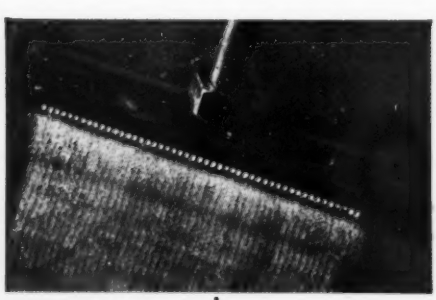
Hand-Cutting

Flame-cutting with manually operated blowpipes is useful for cutting pipe in the fabrication of piping systems. Hand-cutting also is used to cut structural steel in construction or alteration work—to reclaim old pipe—and to cut scrap to length.



Gouging

With Oxweld hand-cutting blowpipes equipped with gouging nozzles, surface metal—such as faulty or temporary welds—can be removed quickly leaving a groove, without need of grinding or chipping, and without harm to the adjacent areas.



Flame-Priming

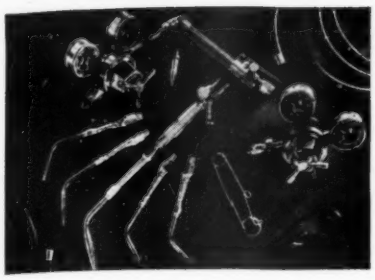
This process removes loose scale, rust, and surface moisture from steel prior to painting—making paint go on faster, bond tighter, and last longer.

Flame-Hardening

This oxy-acetylene process is used to impart a hard, wear-resistant case to steel and iron parts without affecting the toughness of the core.

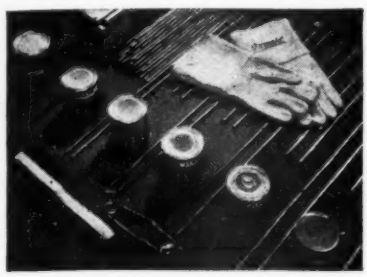
Heating

Heating for bending, straightening, and forming operations is facilitated by the oxy-acetylene flame. Shown here, a pipe is being wrinkle-bent.



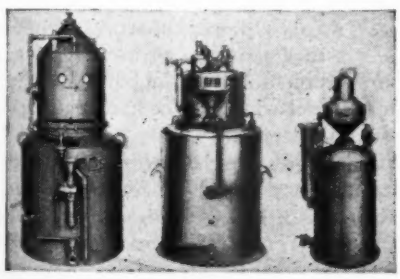
Hand Apparatus

Oxy-acetylene apparatus which may be ordered from Linde includes oxy-acetylene blowpipes for all welding and heating work; oxy-acetylene cutting blowpipes, cutting attachments, and nozzles; and oxy-acetylene descaling and flame-priming equipment. Oxweld apparatus is supplied from Linde offices and warehouses. The Purox and Prest-O-Weld lines are distributed by industrial and automotive jobbers. Prest-O-Lite air-acetylene appliances for soldering and brazing are also distributed by these jobbers.



Welding Rods, Fluxes, and Supplies

Oxweld welding rods and fluxes are of exceptionally high quality. The many kinds and sizes of Oxweld rods make it possible to select the one that will give best results on each job. The Oxweld line also includes gloves, goggles, lighters, hose, ferrules, and asbestos paper. Rods, fluxes, and supplies may be ordered from Linde or from automotive and industrial jobbers.



Generators and Manifolds

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For a more detailed description of Linde processes, and for more information about availability of Linde products, process literature, and process service, send for the descriptive, 8-page catalog shown here.

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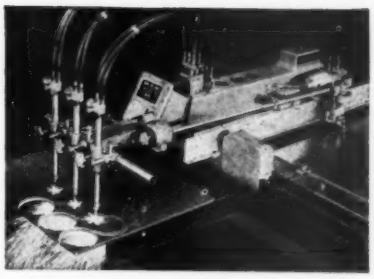

Included in the complete line of Oxweld apparatus are portable and stationary oxy-acetylene shape-cutting machines; straight-line cutting machines; flame-hardening apparatus; bar and billet cut-off machines; equipment for automatic welding; and tractor units for plate-edge preparation.

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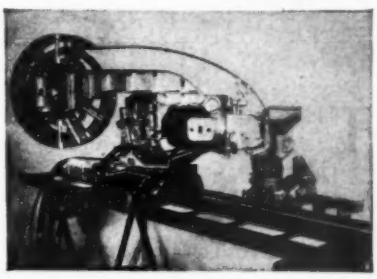

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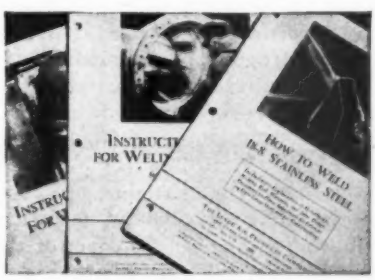
Process Literature



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Oil Test Engine Passes Initial Development Stage

PETROLEUM ENGINEER Exclusive Feature

☆ Crankcase oils evaluated for suitability in full scale engines

by E. W. Jacobson

Design Engineer, Engineering Department, Gulf Research and Development Company

THERE is a great need for a small relatively inexpensive engine in which automotive and aviation crankcase oils may be evaluated so that a reasonably accurate estimate of their suitability for full scale engines may be made.

Oil in an engine is subjected to a very complex set of conditions involving high temperatures, contact with catalysts, mechanical working, and oxidation. This set of conditions varies so much from engine to engine, even of the same make and design that, when standard engines are operated under a fairly standard set of test conditions, correlation between tests of the same oil in different engines and laboratories is quite difficult.

In any full scale engine, breakdown of the oil is the result of many contributing factors. If the effect of these factors in a full scale engine is to be duplicated in a small laboratory test engine, all the factors should be determined quite closely for the full scale engine and then reproduced as closely as possible in the test engine. Most important of the factors contributing to oil breakdown are: Oil consumption and replacement rates, cylinder wall and crankcase temperatures, volume and condition of crankcase atmosphere, metals employed, and makeup of the engine fuel. These factors, in turn, are controlled by: General mechanical condition of the engine in regard to mechanical fits of bearings and pistons, surface finish of rubbing parts, indicated mean effective pressures, area per horsepower, and condition of surfaces exposed to cooling mediums other than lubricating oil, oil pumping rate, etc.

If a test engine is to be useful in duplicating the effect of a wide variety of full scale engines, it must be of a design adaptable to a wide variety of combinations of parts, materials, mechanical fits, surface finishes, methods of cooling, and instrumentation. The Gulf test engine under development at the Gulf research laboratories has been designed with all these factors in mind.

E. W. JACOBSON received a degree of B.S. in M.E., and a degree of professor of mechanical engineering from University of Nebraska—He pursued graduate studies at University of Pittsburgh, Carnegie Institute of Technology, and Rutgers University — With Gulf Research and Development Company since 1933, he supervised design of Gulf amphibian marsh-buggies—Engaged in design and development work on mechanical equipment, automotive engines, automotive laboratory apparatus, precision testing machines for lubrication research—Is now in charge of design section, engineering department.

Description of Engine

The Gulf test engine is a 2-cylinder 90°-V design with a single throw crankshaft, which is basically well balanced for operation at speeds up to 4500 r.p.m. without use of auxiliary balancing mechanism. Also it may be operated as a single cylinder engine. The assembly consists of an unitized crankcase on which can be mounted a wide variety of cylinders, heads, pistons, oil sumps, oil heaters, heat exchangers, etc., to control test conditions as desired. Fig. 1 shows a typical transverse section and Fig. 2 an axial section of the engine. The engine has been designed and built in 3 basic types, L-head liquid cooled, I-head liquid cooled, and I-head air cooled.

Design and construction of a diesel setup is contemplated in the near future. Development and testing on the L-head liquid cooled engine has progressed to the point where success of the design as a test engine seems assured. Development testing of the 2 overhead valve designs is under way. Fig. 3 shows the L-head liquid cooled engine installed on a laboratory dynamometer. Fig. 4 shows the I-head liquid cooled engine and Fig. 5, the I-head air cooled engine.

Design Features

The general design has been worked out with the idea of using standard stock automotive parts wherever possible to reduce replacement costs in routine test work. For instance, the main rod bearings are stock Plymouth parts. The valve mechanisms are made up of a combination of Plymouth and Chevrolet parts, and the air cooled cylinders and valve mechanisms on the I-head engine are stock Continental aircraft engine parts. The liquid cooled designs provide replaceable cylinder sleeves that can be used for a range of bores from 3 in. to 3 1/4 in., and any type of material with surface hardnesses and roughness desired.

Single-piece single-throw crankshafts are used and can be made up to suit the stroke desired. The maximum stroke for which room is provided in the crankcase is 4 3/8 in. An assembled crankshaft with replaceable crankpins could be used. Crankshafts are integrally balanced and separate balance weights to suit piston rods are bolted on to the crankshafts.

Crankcase mounting is such that by dropping the oil sump, bearing shells may be removed for inspection without further dismantling the engine or removing the engine from the stand. The crankcase body is machined smooth inside to facilitate draining the oil and cleaning the surfaces. Camshafts are made in one piece or assembled with separate cams so that valve action may be controlled at will. Valve seat inserts are used. Hydraulic valve lifters are interchangeable with standard lifters.

The lubricating system for the camshaft, cams, cam drive and oil pump drive is separate from the crankcase oil system. Contamination of the crankcase oil by oil from the cam lubricating system is prevented by suitable seals. This also permits measurement of valve stem blowby separate from piston blowby. Means to operate both systems

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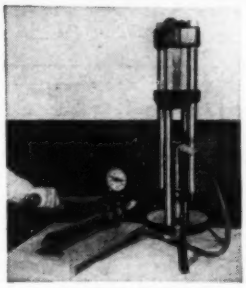

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as one are provided. Either or both systems may be fitted with heaters or coolers to control temperatures independently. The engine may be operated with whatever type oil sump desired. Dry sump operation may be used as conveniently as wet sump. This permits ready control of oil sump temperature and capacity conditions.

Cylinder heads in liquid cooled designs can be cooled separately from the cylinders, permitting independent temperature control for the two circuits. Control of cylinder wall temperatures may be effected by use of suitable insulation on the liners.

The main advantage in the 90°-V design is the inherently good balance of this type without auxiliary balancing. Engines using auxiliary balancing, such as dummy pistons or Lanchester balancers, have the great disadvantage of too large crankcase volume. The Gulf test engine, in all types, operates well at speeds up to 4000 r.p.m. A minor disadvantage of the 90°-V design is that separate carburetors must be used for each cylinder when close control of cylinder power and air-fuel ratio is required. Typical engine data are listed in Table 1.

It can readily be surmised that development of an engine with the flexibility of design of the Gulf test engine involves a wide and extensive series of tests not only to determine performance under varied conditions, but also to find the best ways to control test con-

(Continued on Page 202)

TABLE I

Typical engine design data—Gulf test engine

Cylinder data

Gulf test engine	Cylinder arrangement	Bore, in.	Stroke, in.	Displacement, cu. in.	Maximum hp. at r.p.m. corrected	Maximum ft.-lb. torque at r.p.m. corrected	Compression ratio	Cylinder head material	Cooling medium
2-Cylinder L-head	90° V	3⅛	4⅜	67.11	27.5 at 3770	43 at 2500	6.3	cast iron	liquid
2-Cylinder I-head	90° V	3⅛	4⅜	67.11	27.5 at 3250	51.5 at 1550	6.5	cast iron	liquid
2-Cylinder air cooled	90° V	3⅞	3⅝	85.5	...	...	7.5	aluminum	air

	Piston					Bearings, diam. and length, in.			Connecting rod		
Gulf test engine	Piston wt. with wrist pin and rings, lb.	Piston material	Compression no. and width	Oil rings no. and width	Wrist pin diam. and length, in.	Front main	Rear main	Crank pin	Length, c/c in.	Material	Wt. with cap bushing and bearing, lb.
2-Cylinder L-head	1.719	cast iron	2-3/32	2-1/32	0.859 ×2.62	2.25 ×1.23	2.25 ×1.87	1.937 ×1.00	7 15/16	Manganese steel	1.933
2-Cylinder I-head	1.719	cast iron	2-3/32	2-1/32	0.859 ×2.62	2.25 ×1.23	2.25 ×1.87	1.937 ×1.00	7 15/16	Manganese steel	1.933
2-Cylinder air cooled	1.989	aluminum	3-3/32	2-1/32	0.859 ×3.50	2.25 ×1.23	2.25 ×1.87	1.937 ×1.00	7 17/32	S.A.E. no. 3240	2.605

Valve data

			Spring pressure				Intake					Exhaust					Lift	
			Outer		Inner, if used													
Gulf test engine	Arrangement	Valve seat material	Valve open	Valve closed	Valve open	Valve closed	Maximum head diam., in.	Minimum port diam., in.	Seat angle	Opens	Closes	Maximum head diam., in.	Minimum port diam., in.	Seat angle	Opens	Closes	Intake, in.	Exhaust, in.
2-Cylinder L-head	L	Steel	141	58	.....	.....	1.47	1.31	45°	4° BTDC	56° ABDC	1.47	1.31	45°	42° BBDC	18° ATDC	0.375	0.375
2-Cylinder I-head	I	Steel	141	58	.....	.....	1 47	1.31	45°	3° BTDC	35° ABDC	1.47	1.31	45°	46° BBDC	5° ATDC	0.375	0.307
2-Cylinder air cooled	I	Intake bronze exhaust steel	50	38	32	23	1.56	1.47	45°	10° BTDC	50° ABDC	1.47	1.34	45°	50° BBDC	15° ATDC	0.375	0.375

Fig. 1 (left)—Transverse section of Gulf test engine

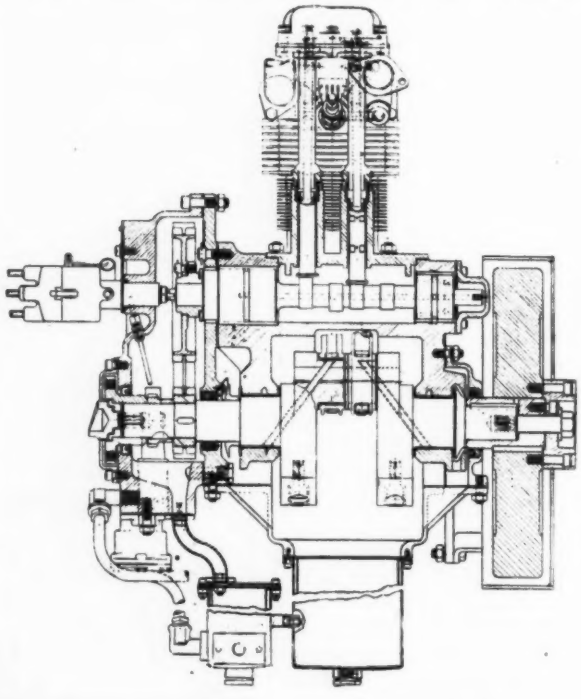
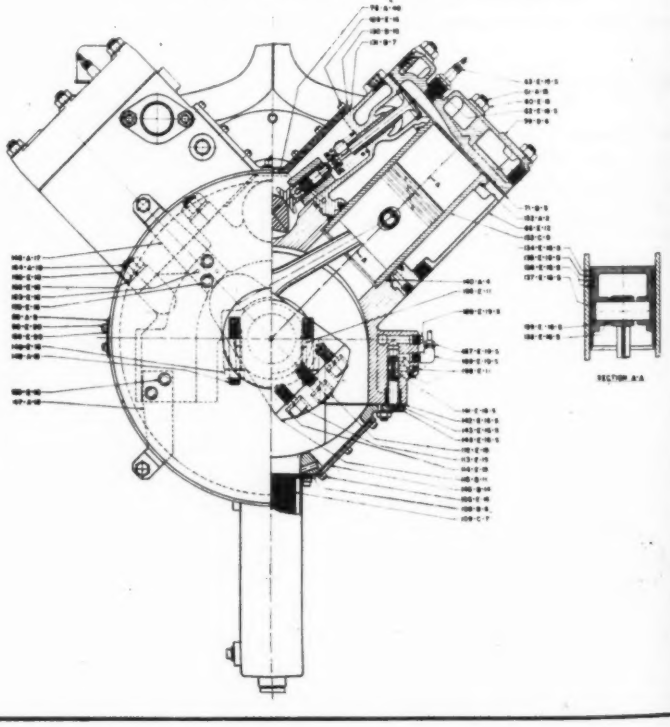


Fig. 2 (right)—Axial section of the engine



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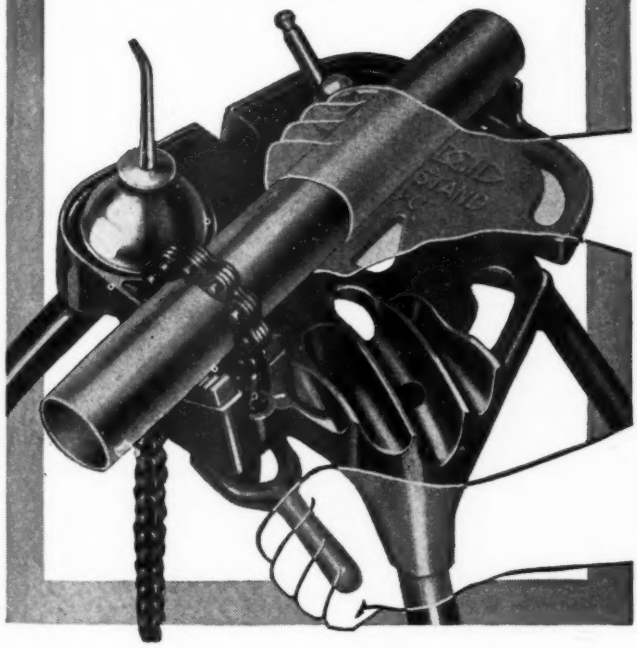

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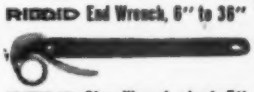

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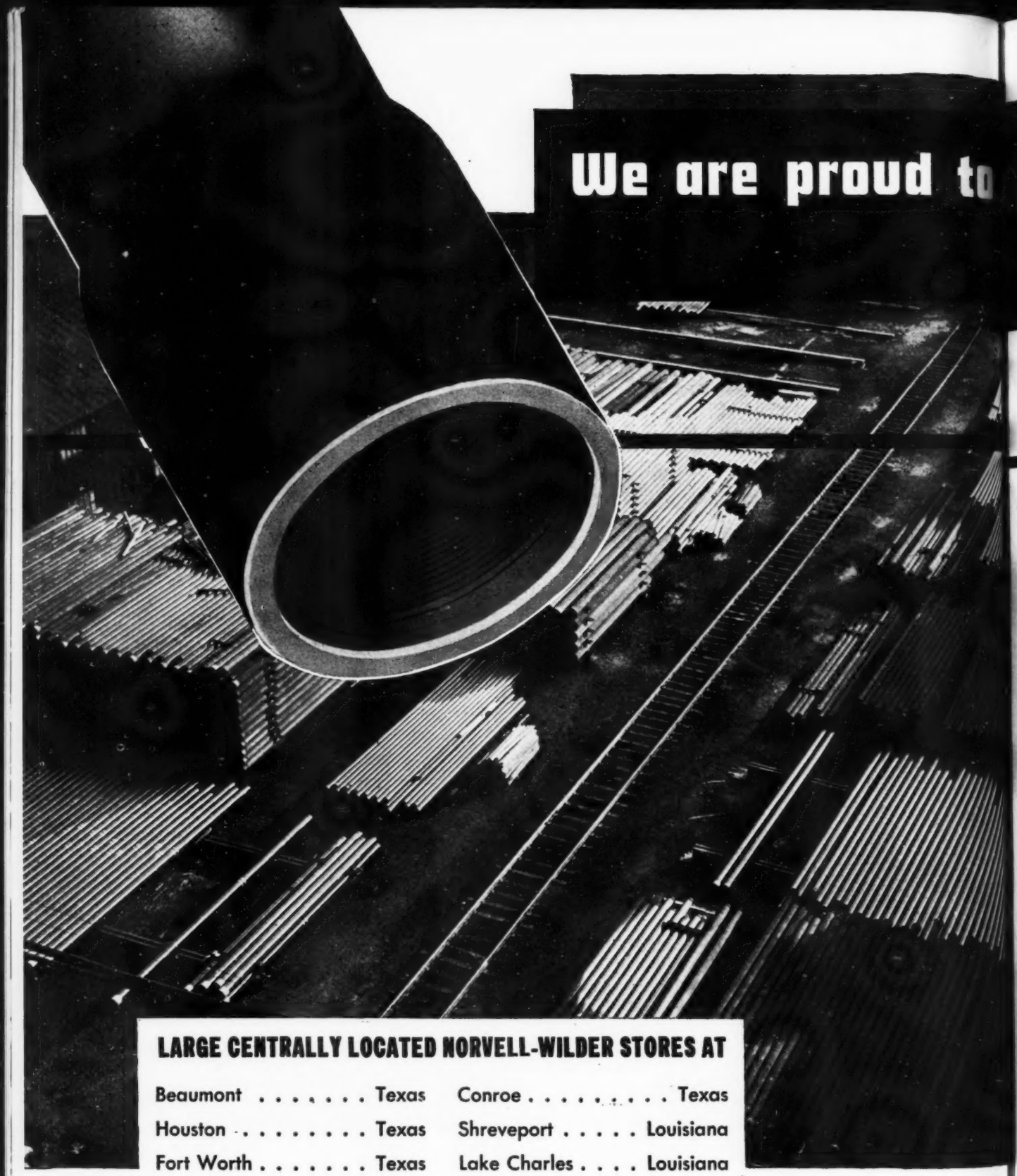

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Gasoline injection, a new method of supplying fuel to the cylinders of gasoline engines, has been perfected and is now in production, Donald P. Hess, president of American Bosch Corporation of Springfield, Massachusetts, announces.

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"The gasoline, by this system, is delivered uniformly to every cylinder of the engine. The result is that all cylinders pull together in harmony, producing a smoother flow of power and quieter engine operation," Hess stated.

Gasoline injection is a method of fuel delivery adapted from the diesel engine, in which fuel is delivered to the cylinders in much the same way.

(Continued from Page 198)

ditions within the close limits desired. A series of such tests have been under way with concentrated effort made on perfecting the L-head liquid cooled design. Once suitable control methods have been worked out on one design, they will apply to a great extent to the other designs, for all designs use the same crankcase.

Control of the oil flow past the pistons into the combustion space is of vital importance in any laboratory test engine. One series of studies has been to test various combinations of piston rings, ring fits, piston clearances, liner wall hardness, and liner wall finish to determine how to control oil consumption within close limits. Such a study takes a surprising amount of testing even when using standard parts. Test data only accentuates the need for development of detailed laboratory techniques where test conditions must be duplicated or correlation of results from several engines is to be obtained.

Once oil consumption has been reduced to a reproductible and controllable minimum, it may then be increased by applying oil by jet to the cylinder walls to give rates of consumption as desired. Such control is desirable especially to reduce the quantities of orginal and replacement oil for any one test, or where piston ring sticking studies are being made.

As stated, the Gulf test engine is being developed for use in reproducing all or only a few of the operating conditions of a multi-cylinder commercial engine, while certain other conditions affecting oil performance are controlled as required, namely, mechanical condition, temperatures, piston speeds, oil consumption rate, power output, manifold pressures, etc. The Gulf test engine, even though originally intended for use only in the Gulf laboratory, may eventually become the basic design for a standard test unit that will give the automotive and oil industries a suitable comparison of values in their lubrication testing and research.

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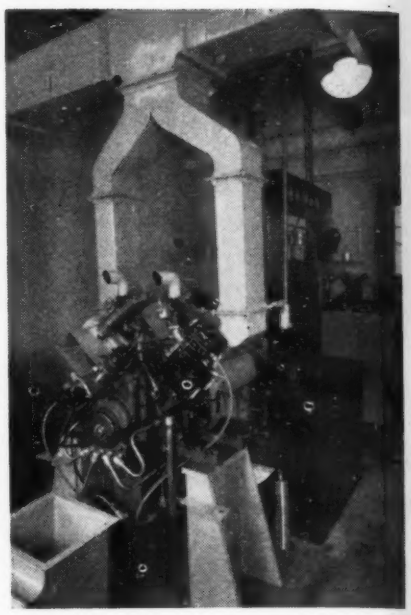


Fig. 5. I-head air cooled engine

Fig. 3. L-head liquid cooled engine

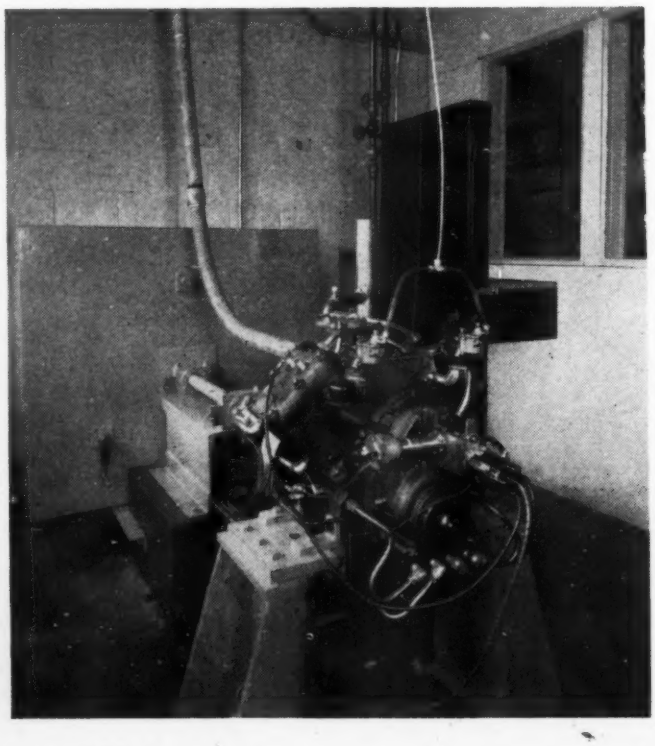
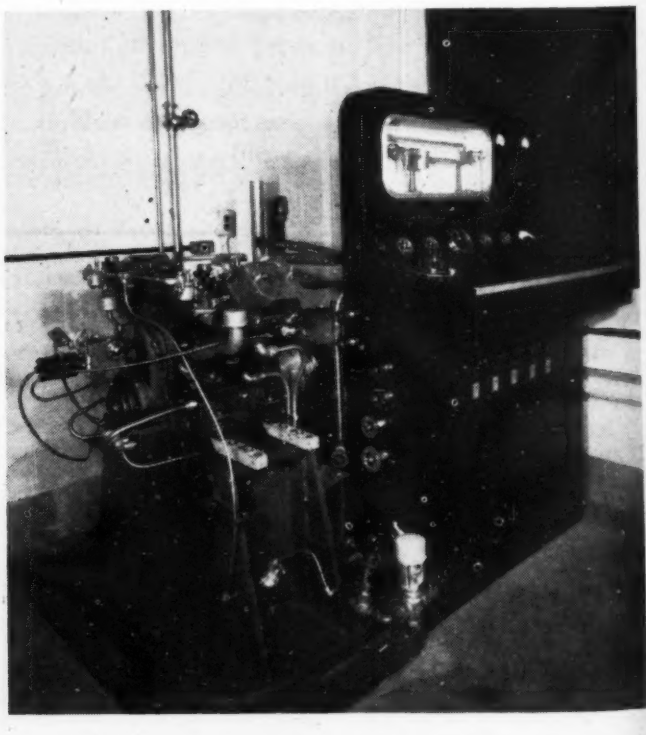


Fig. 4. I-head liquid cooled engine



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☆ Development of additives stimulated by increased power output and high speed of engines

by R. M. Welker

Staff Automotive Lubrication Engineer, Gulf Oil Corporation

USE of additives to obtain special properties in lubricating oils is not new; however, the demand for increased power output from many gasoline engines and the development of high speed diesel engines have stimulated development of additives for engine lubricating oils.

Four general types of additives are in common use:

1. Materials that increase load carrying ability of the oil.
2. Materials that retard the rate of oxidation of the oil under engine operating conditions.
3. Materials that promote engine cleanliness; commonly classed as "detergents."
4. Anti-foam.

These additives may be used either singly or in combination with each other.

More recently, anti-rust agents have come into use in engine lubricating oils to minimize the tendency of engines, which may be stored for long periods of time, to rust.

Bearing design in modern gasoline and diesel engines is ample to carry the load imposed without the use of an additive in the oil. Increased load carrying ability in the oil is, however, sometimes desirable to assist in preventing scuffing of piston rings and cylinder walls, and for this reason, the so-called extreme pressure additives have been used to some extent. Extreme pressure additives commonly used include fatty oils and sulphurized fatty oils, as well as phosphorus and chlorine compounds. Extreme care must be used in the selection of these compounds to avoid possible corrosion of bearings by decomposition products of the additive.

Oxidation inhibitors are of more importance in the heavy duty, high temperature engine field. These additives usually improve the oil in the following respects:

1. Resistance to oxidation.
2. Resistance to increase in viscosity. In extreme cases, viscosity of an oil that is not compounded may increase sufficiently to impair lubrication.
3. Resistance to formation of high temperature sludge and "coffee grounds." This is the high temperature sludge resulting from the formation of solid or semi-solid oxidation products and mixtures of these with dirt, soot, and other foreign materials. "Coffee grounds" are hard, granular materials that usually deposit in the bottom of the oil pan. They may plug oil screens with consequent lubrication failure.
4. Resistance to formation of varnish. The material called varnish, or lacquer, usually desposits on pistons, piston rings, bearings, and other high temperature areas. Ring sticking and, in some cases, actual seizure of pistons or bearings may occur. Varnish also retards proper action of valves by depositing on valve stems and guides.
5. Resistance to formation of soluble oxidation products that are acidic in nature and that may cause corrosion of alloyed bearings.

R. M. WELKER was graduated from the University of Pittsburgh in 1925 with the degree of bachelor of science in petroleum refining—Since that time he has been connected with the lubricating sales department of Gulf Oil Corporation—From 1933 until the present time he has served as automotive lubrication engineer, working with manufacturers of all types of automotive equipment, as well as marine engine manufacturers in the preparation of lubrication recommendations—Has been active in The Society of Automotive Engineers, and is a past chairman of the Pittsburgh section.

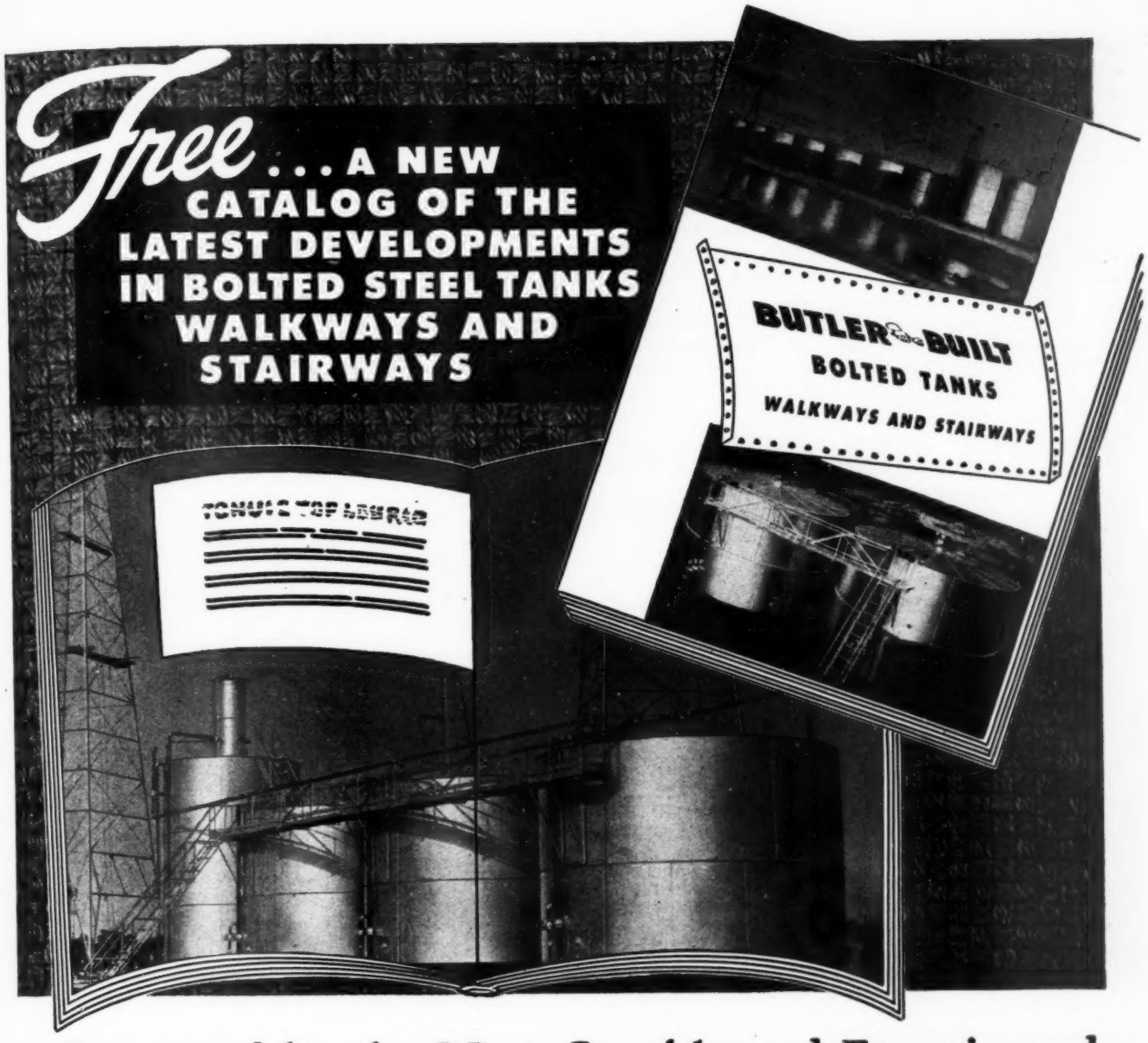
As the normal rate of oil deterioration approximately doubles with each 18° F. rise in temperature, the oil temperature rise encountered in heavy duty operation may, in many cases, make the use of an oxidation inhibitor almost a necessity. In heavy duty truck and bus operation crankcase oil temperatures today frequently run as high as 225° F., and, in many cases reach 280° F. or even higher. Bearing temperatures are usually at least 50° F. higher than crankcase temperatures. The thin film of oil on piston skirts, cylinder walls, and under sides of the piston crowns is subjected to considerably higher temperatures. At approximately 270° F. temperature it is easily possible for the rate of oxidation to be increased to 1024 times the normal slow rate of oxidation occurring at 70° F. The average crankcase temperature does not tell the whole story, because engine design may subject portions of the oil to higher than average temperatures. For example, an exhaust pipe passing down along the oil pan may create a local hot spot, thus in effect, super-heating a portion of the oil.

A large number of oxidation inhibitors are described in patent literature, including certain sulphurized fatty oils or esters, organic phosphorous compounds, amino, phenolic, etc.

At operating temperatures encountered in heavy duty engines, metal surfaces may act as catalyzers to promote more rapid oxidation of the lubricating oil. Copper and iron are particularly active in this respect. In service, protective coatings that lessen this catalytic action are gradually formed over the metal surfaces. Because of the normally slow rate of formation of these protective coatings, however, it is desirable in heavy duty service to use an oil containing an oxidation inhibitor and to change crankcase oil frequently during the break-in period while the protective coating is being formed.

The introduction of hard-alloy bearings such as copper-lead, cadmium-silver, and cadmium-nickel has done much to promote the use of oxidation and corrosion inhibitors. Low molecular weight organic acids, formed by oxidation of certain lubricating oil hydrocarbons at elevated temperatures, may be soluble in the oil. Hence, they will not be removed by a mechanical oil filter. They are quite corrosive to cadmium-silver and cadmium-nickel bearings and selectively remove the lead from copper-lead bearings. Ordinary babbitt bearings are not attacked by these acids.

Detergent oils were originally developed to assist in securing better operation of high speed diesel engines. In these engines, incomplete combustion frequently results in the formation of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excessive amounts of soot as a product of incomplete combustion, particularly under low speed full throttle operation. This soot may be trapped in the piston ring grooves along with oxidized oil and impair proper ring action operation. Further amounts of soot and coke may be formed by actual burning of the lubricating oil film on the cylinder walls during the relatively long combusion period.

Several years ago experimental work indicated that certain materials could be added to the lubricating oil that would keep this soot, together with solid oxidation products and dirt, in suspension and thus prolong piston ring and engine life. These materials are usually referred to as detergents. They are generally metallic soaps or soap-like compounds. Their function is to form a thin film around each individual particle of soot or other solid material in the oil, preventing the particles from joining or coagulating. These soot particles, as formed, are almost colloidal in size; thus they tend to remain suspended in the oil and will be drained from the engine when the crankcase oil is drained if their coagulation is prevented. They are not readily removed by ordinary waste type filters.

As the soot, as well as other solid or semi-solid products of combustion, remains suspended in the oil, the color of detergent oils may darken rapidly with use. This finely divided material, in reasonable concentration, apparently does no harm to the engine so long as it remains in suspension. Prolonged use of crankcase oil, however, may result in accumulation of more solid material than can be kept in suspension by the detergent. When this occurs, the excess may settle out and deposit at points of low oil velocity, such as behind piston rings; or it may be thrown out in the drilled passages of the crankshaft by centrifugal action. It should be emphasized, therefore, that the use of a detergent oil does not eliminate the necessity for periodic crankcase oil changes.

Detergent oils were first developed for use in engines equipped with conventional high tin babbitt bearings. As these oils came into wider use it was found that some of the most successful types were highly corrosive to some of the newer alloy bearings, particularly those of the copper-lead type. Further research led to the development of new formulas, which included oxidation and corrosion inhibitors as well as detergents, thus producing detergent oils suitable for every type of bearing.

The Caterpillar Tractor Company took a leading part in this work and developed a series of laboratory and field tests designed to evaluate oils for use in engines of their manufacture. These tests include:

1. Caterpillar Class 1 test. A 480-hr. single cylinder engine test designed to determine the piston ring sticking and varnish formation tendencies of the oil. This is classed as an endurance test.

2. Caterpillar Class II test. This is a short test run with the injector nozzle set in such a position that the flame impinges against the cylinder wall. Hard carbon formed by decomposition of the lubricating oil on the cylinder wall will cause objectionable scratching of the aluminum piston, particularly above the top piston ring. This is designated as an accelerated run-in and high load test, and is usually referred to as the "scratch test."

3. Caterpillar Class III test. This is a 120-hr. test run to simulate high atmospheric temperature operating conditions. The air-intake on this test is maintained at 90° F. The engine used has four cylinders, copper-lead bearings in two connecting rods, and babbitt bearings in the remaining two. Bearing corrosion and engine cleanliness are checked. This is usually referred to as the "hot box test."

These tests are required for evalua-

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tion of additive-oil combinations where field service data is available on the additive. Exhaustive field tests are required to evaluate oils containing new additives.

Similarly, the General Motors 500-hr. endurance test was devised to test heavy duty oils for use in the General Motors Series 71 diesel engine. The oil is run in the engine under full load without crankcase oil change for the full 500 hr. Cleanliness of the engine after test and condition of the copper-lead bearings are used in evaluating the oils.

An additional engine test, now widely used in the evaluation of the heavy duty oils, is the 36-hr. Chevrolet test. This test is run in a 1941 Chevrolet engine with the crankcase oil temperature maintained at 280° F. Copper-lead bearing inserts are used in two of the six connecting rods. The engine is run at a speed equivalent to 60 m.p.h. and road load—approximately 30 hp. Cleanliness of the engine and bearing weight loss are measured.

The five tests mentioned have been recognized by the Coordinating Research Council and have been assigned C.R.C. designations. Table 1 shows these five tests together with the test conditions.

Although an oil may pass certain of the abovementioned engine tests with the addition of only a good oxidation inhibitor, it appears necessary to have both a good oxidation inhibitor and a good detergent to pass all tests. As a matter of fact, oils may operate satisfactorily in the Caterpillar engine, for example, but may not be acceptable for the General Motors Series 71 diesel engine or the Chevrolet engine. Likewise, an oil that is satisfactory in the Chevrolet or General Motors diesel engines may not pass the Caterpillar ring sticking and "scratch" tests.

For this reason there is need for a single laboratory test engine designed with sufficient flexibility that conditions duplicating not only the operating conditions in the above engines, but any full scale engines in general, may be duplicated in the single engine. The Gulf Laboratories have developed a small 2-cylinder 90°-V type engine that is exceedingly flexible in its operation for this type of test work. This or a similar engine may eventually be adopted as the standard test engine by both the oil industry and the engine manufacturers.

In addition to selection of the proper additives, careful consideration must be given to the base oil stock of heavy duty oils. In the Caterpillar tests base oil stocks containing appreciable percentages of bright stock may form hard abrasive carbon that may cause excessive cutting and scratching of the piston and cylinder walls. On the other hand some conventionally refined naphthenic oils with their naturally lower resistance to oxidation may result in excessive engine deposits in the General Motors diesel engine and Chevrolet tests. Solvent processed naphthenic base oils seem to be better suited than conventionally refined naphthenic oils for this work.

The widest application of these new heavy duty detergent type oils is made by the U. S. Armed Forces. In an effort to simplify the problem of supply to the forces in the field a lubricating oil specification was devised to describe an oil that would be satisfactory for use in the engines of all types of vehicles used by the ground forces. As these include nearly all types of automotive diesel engines, as well as both conventional truck and passenger car gasoline engines and radial aircraft gasoline engines, it was obvious at the beginning that the adoption of one type of oil for so many different type engines would be a radical departure from former practice. Because of the success of detergent type oils in diesel engines this type oil was selected.

Because of the many difficulties in writing a specification that will insure satisfactory performance incorporating

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only the usually accepted tests such as gravity, viscosity, flash, fire, pour, carbon residue, color, etc., it was considered necessary to include actual engine tests in this specification; therefore, the Caterpillar, Chevrolet, and General Motors diesel engine tests, as previously described, were included. As it is not practical, however, to run these exhaustive engine tests on each lot of oil purchased, the U. S. Army Ordnance Department set up the Ordnance Reviewing Board, which passes on the qualifications of each brand of oil and issues qualification numbers to those meeting all requirements. Thereafter, so long as the make-up of the oil is not changed, subsequent lots need only to be checked for such physical characteristics as viscosity, viscosity index, pour and flash point. In addition, a low temperature stable pour-point test is required for the S.A.E. 10.

Field experience by the army has indicated a tendency for the lubricating oil to foam in certain types of engines. To evaluate the foaming tendency of an oil, a foam test has recently been incorporated in the army specification oil requirements. The Ordnance Reviewing Board passes on the resistance to foaming of qualified oils. The most advanced types of detergent oils now incorporate an anti-foam agent in their formulas.

To further simplify the supply problem, the army has limited its requirements to three S.A.E. grades, namely, S.A.E. 10, 30, and 50. For commercial use S.A.E. 20 and 40 grades can be obtained in some brands when desired, but army experience is apparently proving that three grades should be sufficient in our postwar requirements.

Although detergent oils appear to have properties that suggest their adoption for heavy duty work in many fields, it is desirable to consider carefully each particular application before making a change to these oils after equipment has been operating on a straight mineral oil. Experience has indicated that detergent oils not only help to keep a clean engine clean, but may have a definite washing action in the interior of the motor. These oils, when installed in a dirty engine, may carry deposits from a place in which they do little or no harm to a place such as the oil screen where they may cause trouble.

When installing detergent oils in any but a new, or newly reconditioned engine, the engine should be thoroughly flushed and the oil filter cartridge renewed before installing the detergents, to remove as much of the accumulated dirt as possible. Crankcases should be drained at least twice at 500-mile intervals and then at a 750-mile interval before going to the regular drain periods. Where engine oil drains are on a time basis, the first two drains should be at not more than 25-hr. intervals. After this, two drains should be made at not more than 50-hr. intervals, after which it may be satisfactory to extend the drain intervals. These suggestions are based on average operating conditions and may be varied somewhat depending on such factors as the condition of the engine, type of service, and potency of the detergent.

As previously outlined, it is possible for the detergent material to become exhausted in service. This is also true of oxidation inhibitors. When detergents or oxidation inhibitors have been exhausted, the lubricant becomes just a dirty crankcase oil. That is why it is highly desirable to establish a regular crankcase oil drain period on a mileage or on an engine hour basis, whichever is more convenient.

The use of detergent oils complicates the problem of filtering the oil as has already been indicated. As the particles of soot are practically of non-filterable size, only the larger particles of dirt will normally be removed in the conventional waste type filter. Actually a new charge of detergent oil may remove dirt from a dirty filter cartridge returning it to the oil. It is, therefore, important to renew the filter cartridge at least as often as the oil is changed.

Oil filters may remove some of the detergent from the oil; however, the benefits to be derived from a good filter makes its use desirable. The removal of a small percentage of the detergent should not be considered too objectionable unless sufficient to seriously impair the special ability of the detergent oil to maintain a relatively clean engine and keep piston rings free under heavy duty operation.

Ordinary earth type filters can be expected to remove detergents much more rapidly than do bag or waste type filters. For this reason earth type filters are not generally recommended for use with detergent oils. Some manufacturers of earth type filters now market special cartridges for use with detergent oils.

Although these oils for the most part have been used principally in gasoline and diesel engines up to 250 hp., their use in larger engines such as for railroad service is being considered.

The navy permits the use of detergents in engine oils that are approved for use in submarine diesel engine service. Recently some work has been done to determine the suitability of these oils for commercial aircraft engines. Undoubtedly the future will see the use of detergent-type oils extended even further.

——— ☆ ☆ ☆ ———

TABLE I

C. R. C. designation	C. R. C. L-1-243	C. R. C. L-2-243	C. R. C. L-3-243	C. R. C. L-4-243	C. R. C. L-5-243
Engine builder's designation	Caterpillar No. 1 class	Caterpillar No. 2 class	Caterpillar No. 3 class	Chevrolet 26-hr. test	G. M. Series 71 diesel
No. of cylinders	Single cylinder	Single cylinder	Four cylinder	Six cylinder	3, 4, or 6 cylinder
Purpose	Ring sticking and endurance test	Accelerated run-in and high load test (scratch test)	Oil stability and bearing corrosion test (hot box test)	Oxidation stability and copper lead bearing corrosion	500-hr endurance test
Engine speed	1000 r.p.m.	900 r.p.m.	1400 r.p.m.	3150 r.p.m.	2000 r.p.m.
Load (b. hp.)	19.8	Power output at definite fuel rate 60 cc.—90 cc./min. Approx. 15 b. hp.	37	30	27 per cylinder
Crankcase oil temperature	145-150°F.	135-145°F.	210°F.	280°F.	230°F.
Jacket water outlet	175-180°F.	170-180°F. 135-145 on SAE 10	200°F.	200°F.	180°F.
Oil consumption				S.A.E 30 and 50 oils 0.07 to 0.12 qt. per hr. S.A.E. 10 and 10W oils 0.08 to 0.15 qt. per hr.	Max. 0.07 lb. per hr. per cylinder
Connecting rod bearings	Babbitt	Babbitt	2 babbitt and 2 copper lead	Babbitt—2 copper lead	Copper lead
Length of test	480 hr.	3 tests—3½ hr. each	120 hr.	36 hr.	500 hr.
Oil change interval	110 hr.	After each test	None	None	None
Special conditions		Air inlet 90°F. Oil pressure —30 lb. per sq. in. Special pre-combustion chamber			

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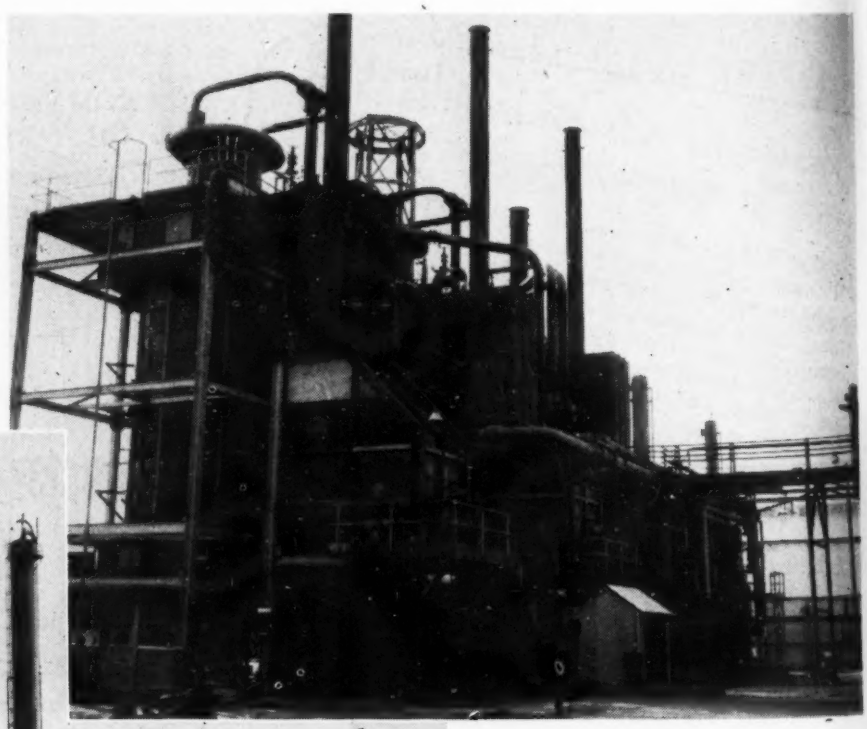
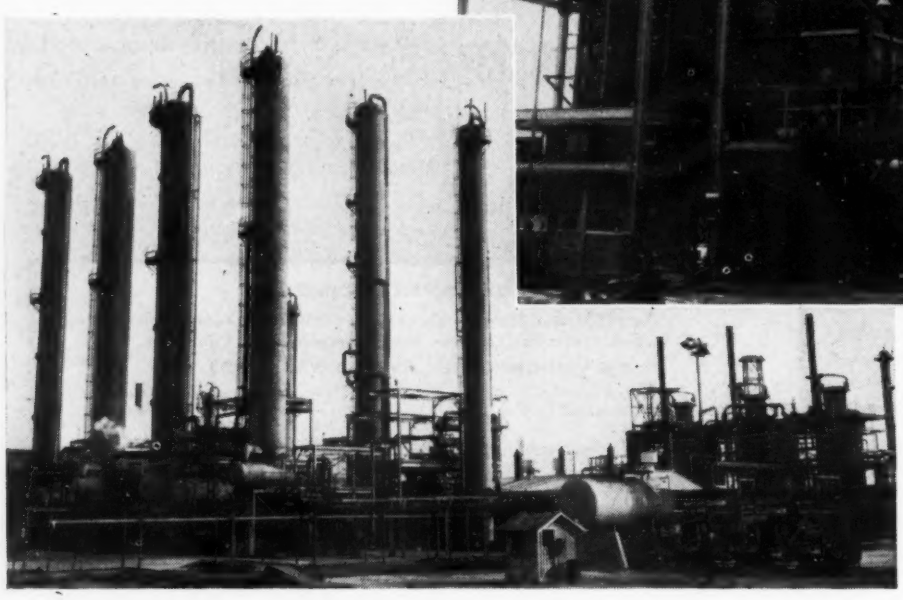
Information on the progress of construction and operation has naturally been withheld but censorship on generalized description of refining processes has now been raised. Although attention has been focused on 100-octane aviation fuel because of its use in highly dramatic operations and on synthetic rubber because its availability touches the lives of nearly everyone of us, other vitally important petroleum products have to be supplied by the refining industry. Among these is synthetic toluene that is a basic ingredient of TNT, the high explosive so widely used in warfare, providing the devastating effect of the "block-busters" that are being used extensively in aerial bombardment.

Toluene has generally been considered as a coal tar derivative but several years ago research work was begun by Shell Oil Company, Inc., to develop a process for producing toluene from petroleum. That was the beginning of the Shell toluene recovery process, which is now widely licensed in America and which is said to be the source of more than one-half the nation's toluene production. Development of a highly technical process for synthesizing toluene from petroleum followed research and this one company's plants alone are now producing more toluene than was produced in the entire United States prior to the war.

The demand for toluene after the outbreak of hostilities naturally became acute and Shell proceeded to build its first toluene plant in the west at the company's Wilmington, California, refinery. This plant was completed at a cost of $4,800,000 without recourse to government funds, and by December 1942, one year after Pearl Harbor, the first nitration grade, or high purity, toluene was produced. Production subsequent to that time has exceeded advanced estimates and this one plant is producing sufficient toluene per day to fill 700 of the largest "block-busters."





Below, 8-column feed prefractionation and solvent extraction units; right, close-up of dehydrogenation reactor furnaces at toluene plant.

Almost no waste products result from the operation of the plant because it has been designed to produce a maximum quantity of toluene from the crude oil without unnecessary sacrifice in other products. Since being put on production the entire output has been supplied to the U. S. Army Ordnance.

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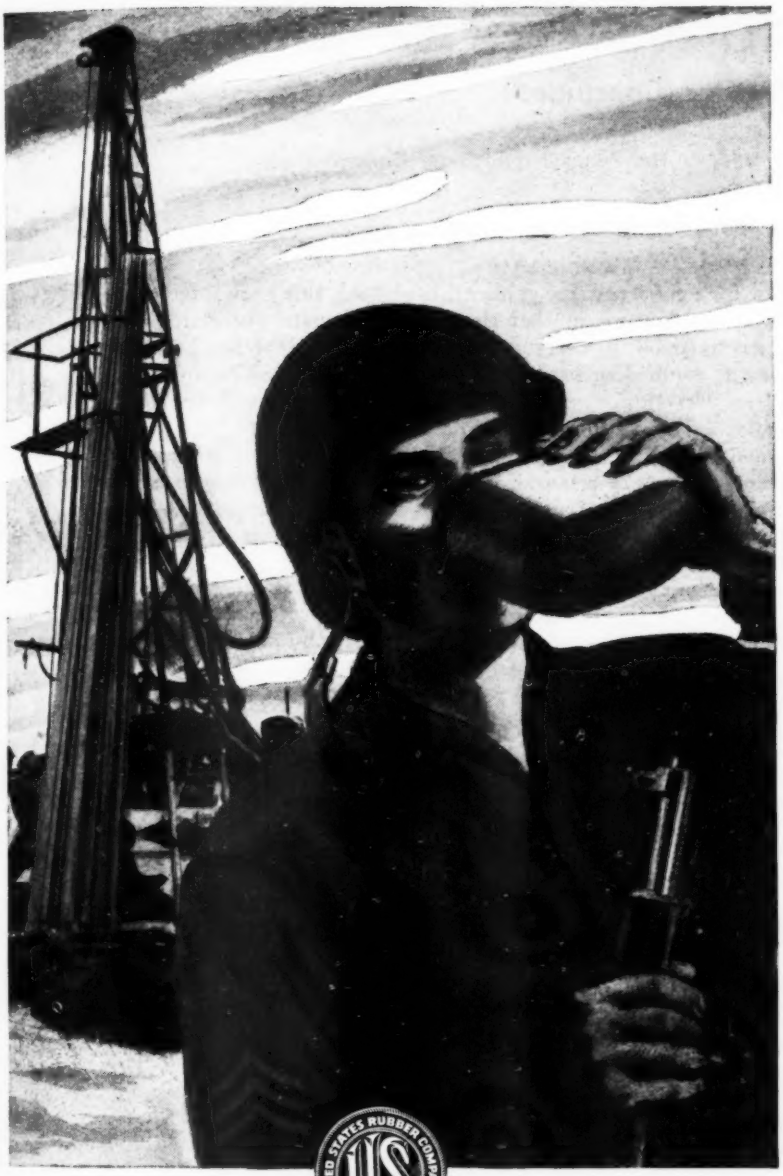

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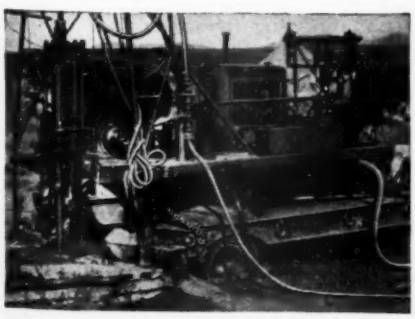

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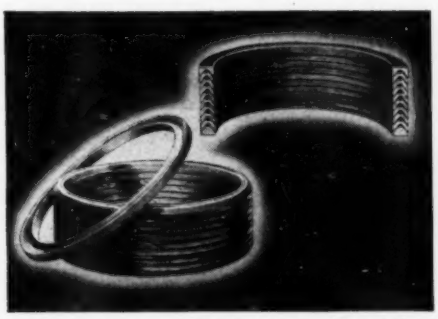

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The Drowning and Revival of Gas Wells

PART 2 (Concluded)

by S. T. Yuster, The Pennsylvania State College
and
K. J. Sonney, United Natural Gas Company

Action of Treating Liquids

The question naturally arises at this point regarding what is the mechanism of the action that brings back the rate of flow in a drowned sand. On the basis of Raoult's law, the vapor pressure of water in an ideal solution is decreased by the presence of a second liquid. According to Raoult's law:

$$p = P x \quad \ldots\ldots\ldots\ldots\ldots\ldots 7$$

where p is the partial vapor pressure of the particular component above the surface of the liquid mixture; P is the vapor pressure of the pure substance at the given temperature, and x is the mole fraction of the component in the mixture.

As x is always less than one in a mixture, p is less than P and the partial vapor pressure of a component in an ideal mixture is less than in the pure state at the same temperature.

The vapor pressure of a mixture can be greater, however, than the vapor pressure of one of its components in the pure state. Fig. 12 shows the vapor pressure of acetone-water mixtures and the partial vapor pressure of water for comparison. These curves were constructed from data taken from the International Critical Tables.

As a mixture of acetone and water evaporates the most volatile constituent, which is acetone in this case, passes off in the greatest proportion. The vapor pressure of the mixture should, therefore, decrease as the process of vaporization proceeds. This will tend to slow down the rate of liquid removal. This change in vapor pressure with composition is shown in Fig. 12. In the case of acetone-water mixtures, the partial pressure of the water is slightly greater than that of pure water at the same temperature, due to the departure of the mixture from ideal behavior. This is advantageous for it aids in the removal of the water from the producing formation.

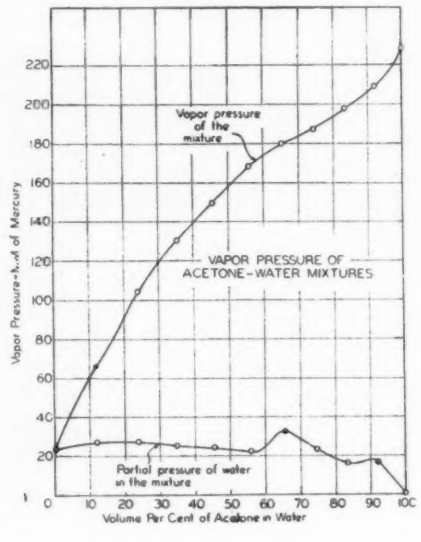
It is the increase in vapor pressure of the mixture over that of the pure water that seems to be the important fact in the unplugging process. The gas, in penetrating such a mixture contained in the pores of a sand, creates a surface from which evaporation can take place. If the evaporation is rapid, the size and number of channels available for gas conduction will be increased; this in turn increases the rate of gas flow for a given pressure gradient. The increase in flow means that there is more gas available to carry off the liquid in the sand. The process is in effect self-accelerating.

It should be kept in mind that surface tension does play a small part in the process because the penetration of the gas into capillaries is controlled by it. Equation 3 gives this pressure of penetration, which is directly proportional to the surface tension. The greater the surface tension the greater the pressure necessary for penetration. The lower the surface tension, the greater the number of capillaries penetrated for a given pressure, as it will bring some of the smaller radii into action. It is fortunate that the higher vapor pressure liquids that are miscible with water also lower its surface tension.

Results

Although these results on the revival of drowned gas wells appear quite promising from a laboratory standpoint, great caution should be used in applying the knowledge in the field. Sand conditions may be very complex, involving a heterogeneous permeability profile and horizontal variations in permeability. The size of the laboratory sand bed is extremely small as compared with that existing in the field and it is difficult to translate the small scale experiments directly to the field. In applying this knowledge it would be well to estimate, for example, the quantity of water that has penetrated the sand body and how far in it has gone. Such information will be a guide for the treating process.

Fig. 12. Vapor pressure of acetone-water mixtures



It should be remembered that the treating liquid must mix with the water in the sand and in order to do this it must penetrate. If the liquid does not penetrate the formation easily it will be necessary to force it in with a gas pressure supplied by a compressor or a high pressure gas line. It is also more effective if it is forced in for some distance.

Future Work

No laboratory water coning experiments were tried for the removal of a water cone, but the liquids discussed in this article may have some application to that problem. This refers to an abnormal cone formed during uncontrolled flow and not to the cone that seems to be a necessary evil accompanying normal gas or oil production in a reservoir with a gravity segregation of water and hydrocarbon fluid.

Other treating fluids should be tried in this work. The possibility of using dimethyl ether suggests itself because of its high solubility in water and high vapor pressure. Such mixed ethers as methyl-ethyl, methyl-propyl, methyl-*iso*propyl, and others may show certain properties that would be advantageous in the unplugging action.

Although acetone was the most satisfactory single compound used, the addition of 10 per cent of diethyl ether to it improved its unplugging action to a marked extent. This composition was used because it is fairly close to the safe maximum ether tolerance of a water and alcohol mixture, miscible with water in all proportions, and would not, therefore, result in the separation of two phases as the mixture penetrated the sand. It was felt that separation into phases upon dilution with water would not only prevent the treating liquids from being used to their maximum advantage but in addition a liquid-liquid Jamin action would be superimposed on an already complicated picture. If phase separation is prevented by the proper blending binary or even trinary mixtures might be used to advantage.

Even though treatment with a solu-

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tion of a wetting agent showed only slight benefit, further studies should be made in which other surface modifying chemicals are used either alone or in conjunction with volatile water-miscible fluids already mentioned. The ideal treating fluid is one that forms a high vapor pressure and low surface tension mixture with water and one that is low in cost. Substances satisfying these conditions should be effective.

Conclusions

1. It appears that Jamin action is almost wholly responsible for the plugging action of water on gas sands.
2. This Jamin action may be overcome by the addition of certain liquids to the water in the sand.
3. The important function achieved by the action of these liquids is to increase the vapor pressure of the solution in the sand. Therefore, the more volatile the liquid the better, if it is sufficiently soluble in water.
4. From an economic standpoint acetone appears to be the most satisfactory liquid with the possibility of adding 10 per cent of ethyl ether to it for further improvement.
5. The lower the permeability of the sand the greater the gas pressure gradients or the greater the number of injections of the treating liquid necessary for unplugging.
6. The treating liquids are usable even when the well has been drowned with connate water.

Safe Drowning of Gas Wells

In some cases it may be necessary to drown a gas well but it is desirable to do so under controlled conditions that will enable the operator to bring it back to normal production at will. This would be advantageous in bringing a wild well under control or when special treatment is necessary on an already completed well. One of the first thoughts would be the use of a mixture of water and one of the liquids (such as acetone) mentioned before. Although such a mixture is infinitely better than water alone there are still better ones available. The vapor pressure of these mixtures is limited by the vapor pressure of the liquid added to the water. As there is usually no water in the producing sand of the well to be "killed" the drowning liquid need not be miscible with water in all proportions. About the only condition necessary is that it has a higher vapor pressure. Natural gasoline is such a liquid.

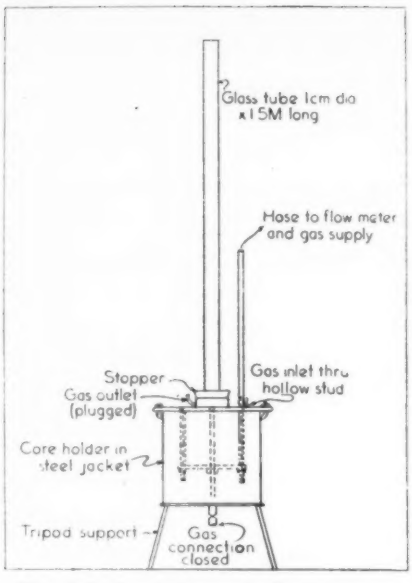

Fig. 13. Arrangement of apparatus for drowning tests

The principle of killing a well is dependent upon applying a column of liquid in the well that exerts a pressure at least equal to the formation pressure. Natural gasoline might be used for the purpose under certain limited conditions if the formation pressure is relatively low. If the bottom hole pressure in the well is greater than the head of gasoline in it, it will not be possible to kill the well with this liquid. If a volatile liquid having a density equal to, or greater than, that of water could be used, it would be highly advantageous. Examples of liquids of this type are the chlorinated hydrocarbons such as carbon tetrachloride (sp. gr. 1.595), or mixtures of hydrocarbons such as natural gasoline and carbon tetrachloride in the proper proportions. Such mixtures can be adjusted to any density within the range of the components.

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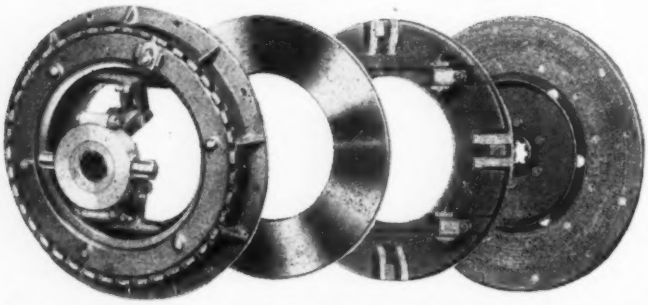

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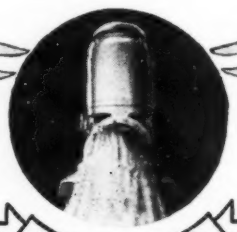

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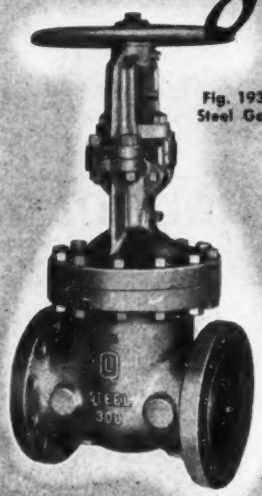

Fig. 1938
Steel Gate

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Fig. 1430
Iron Body Gate

Fig. 1640
"King-clip" Gate

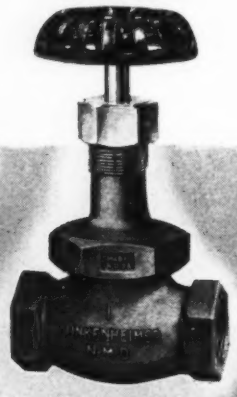

Fig. 123
"N-M-D" Globe
(Non-Metallic Disc)

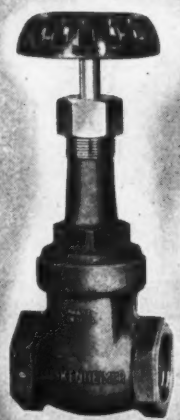

Fig. 2125
Bronze Gate

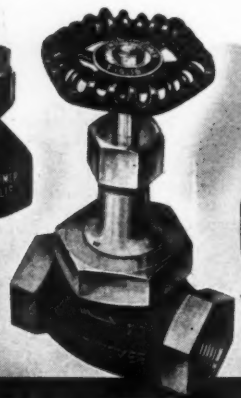

Fig. 16
"Renewo" Globe

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Although the mixture alone can be used for killing a well, it may be too expensive to fill the well bore with it. If some sort of packer arrangement with very small tubing to the surface could be set in the well, the head of liquid could be obtained without excessive quantities of liquid being necessary. It is possible, however, to use a relatively small quantity of the volatile water-immiscible liquid along with a large quantity of water. If the volatile liquid mixture is adjusted to a density greater than that of water, it may be poured or lubricated into the well in such quantities as to wet the sand and extend up into the well for some convenient distance. If water is poured into the well after it, the water, being the lightest of the two liquids, will float on the volatile liquid. Sufficient water is then added to kill the well.

There will be some tendency for the volatile liquid to penetrate the formation and if the proper precautions are not taken, the water will finally enter the sand, a condition that must be avoided. In order to eliminate this danger, more volatile treating liquid might be poured on top of the water and, being heavier than it, will go to the bottom of the well and prevent the water-hydrocarbon liquid interface from touching the sand. The rate of adding this liquid should be determined by the rate at which the well takes liquid during the shutdown and the rate at which the added hydrocarbon liquid falls through the water column. After the conditioning of the well has been completed, the water can be removed and the volatile liquid will be evaporated by the gas in the formation.

Experimental Method

The apparatus shown schematically in Fig. 13 was used to test the possibilities of the theory just discussed. A core held in the usual coreholder was placed in a pressure pot that rested on a tripod. A long glass tube was inserted into a stopper and placed into the outlet end of the coreholder. This acted as well tubing. Dry compressed air was used as the gas and injected into the pressure pot so that it flowed radially through the core and out the well tubing. Liquids were poured into the glass tubing until the flow of gas ceased, and as the level decreased due to penetration in the sand, sufficient liquid was added to maintain a safe head and prevent blowouts.

After the laboratory "well" had been dead for some time, the head was lowered by removing some of the liquid, thereby permitting gas flow from the well to be resumed. Observations were then made to determine if the original rate of production could be regained. In every case the return to normal production was extremely rapid and no dif-

ficulty whatsoever was encountered in removing all the treating liquid. The well could be kept killed for any desired length of time. In the experiments in which water was used with the hydrocarbon liquid, the treating liquid was poured into the tube until a sufficient quantity had been injected to keep the sand face covered with it. Water was then poured in until all gas flow had ceased. As the fluid level declined, a carbon tetrachloride-natural gasoline mixture was added in sufficient quantities to maintain the liquid level up to the point where no gas flowed from the sand. It was not possible to carry out any extended experiments on this particular phase of the work due to the small size of equipment.

Calculations of the rate at which the treating liquid will fall through the water column may be attempted by means of Stoke's Law as follows:

$$V = \frac{2\,g\,a^2\,(d_1 - d_2)}{9\,Z} \quad \ldots\ldots 8$$

where V is the velocity of fall in centimeters per second of sphere having a radius of a centimeters and a density of d_1 (gms. per cm.^{2}) in fluid of density d_2 and having a viscosity of Z poises; g is the acceleration of gravity (980.6).

For the particular conditions used in this work $d_1=1.135$, $d_2=1.0$, and $Z=0.01$. Then $V=0.155\,a^2$ in which V is now given in the velocity of fall in ft. per sec. and a the radius in centimeters. A sphere of the treating liquid having a radius of 1 cm. will fall through the water column in the well at a rate of 0.155 ft. per sec. and having a radius of 2 cm. will fall four times as fast.

It can be seen that this rate may be too slow for deep wells or where the sand may take the treating fluid at a fairly rapid rate. Under such circumstances it might be well to inject the treating fluid into the bottom of the well through macaroni tubing.

From the results of these experiments it would seem that it should be possible under specialized conditions to kill a well by the methods just discussed. With extremely high pressures in a wild well it is doubtful whether these methods can be adapted.

Acknowledgments

The writers wish to thank J. G. Montgomery, Jr., vice president, United Natural Gas Company, and Dr. A. W. Gauger, director, Mineral Industries Research, Pennsylvania State College, for their suggestions and criticisms during this work. Acknowledgments are also due to the members of the Petroleum Production Research staff at Pennsylvania State College with whom this problem was discussed.

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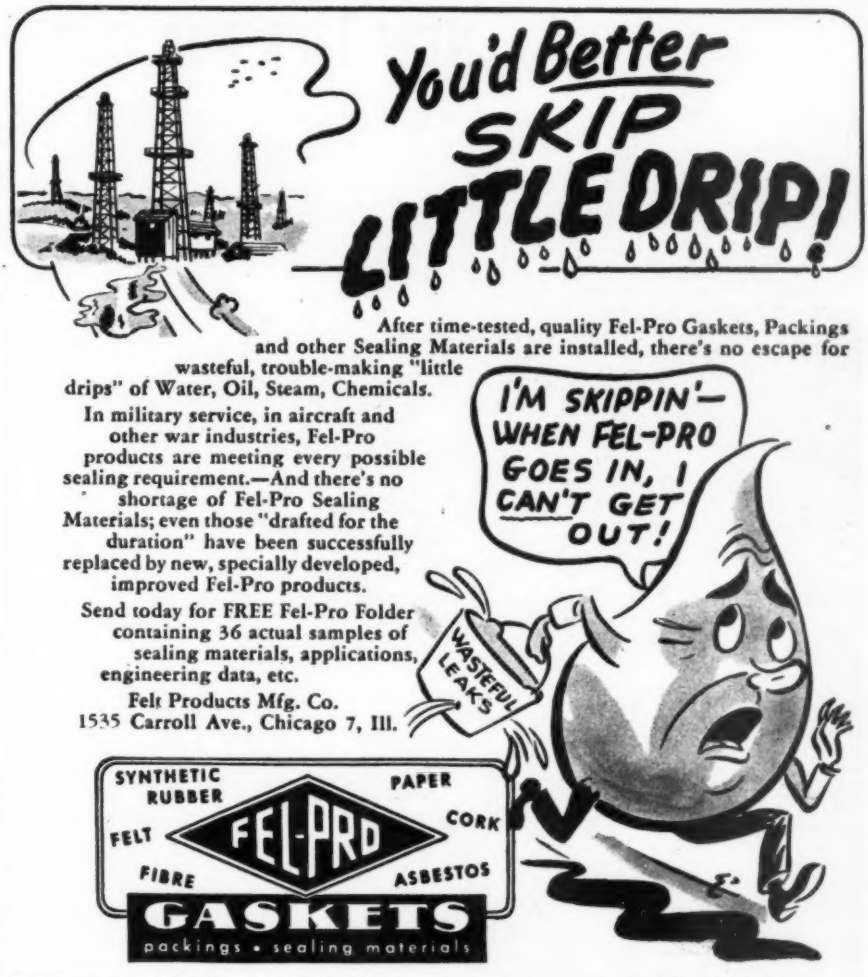

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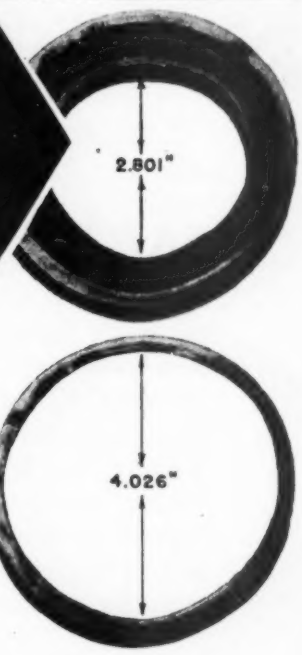

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Concepts and Methods of Cathodic Protection

PART 3 (Concluded)

by J. M. Pearson
Susquehanna Pipe Line Company

THE step by step procedure in solving the problem introduced at the conclusion of the last installment of this article may be outlined as follows:

(1) Of the feasible locations of A, for example along line C—Z, one must be chosen for which the drainage requirements of B are a minimum.

(2) With the anode suitably located current requirements for polarization of the protected line are determined in the corrosive area.

(3) The distribution of anode current in the foreign structure is determined, with B open. Data is examined to find the region of densest current discharge due to the anode current.

(4) Terminals 2 are set up, installing a permanent ground stake as the positive terminal. (We use one terminal to illustrate, where several are advisable in the field). The values of $R_{2,1}$ and $R_{2,B}$ are measured.

Data (3) and (4) are to determine the resistance of the bond that will carry enough current to cancel out the discharge in the most exposed region of the foreign structure. (Of course, if the foreign structure is to receive some cathodic protection, the current density required must be related to the bond current and the coupling to the anode, so that sufficient drainage is obtained to achieve the desired result.)

(5) With the anode circuit open, the distribution of bond current in the protected line is measured by introducing the test current at B.

The point on the protected structure at which bond current is lost at the highest rate is determined by examination of the data of (5), and a permanent ground stake installed to form, with the line, terminal pair 3. The value of the coupling resistances $R_{3,1}$ and $R_{3,B}$ are measured.

The ground stake at terminal 3 is usually placed over the line or reasonably close to it. So long as the same stake is used for all readings at 3, the data will be consistent. A permanent stake is used so that a check can be made later if needed. (Actually several terminals would be set up in this region so that more than one check can be obtained.)

Data (5) are to determine and account for the reduction in cathodic protection by the bond current on the protected structure.

(6) With the design and installation complete, both lines should be examined at several points to determine the effectiveness of the design.

It is clear, from a practical viewpoint, that some of the above steps can be combined to save time in the field work. The steps are arranged better to illustrate the logic of the procedure than the practice. For instance, when the current supply generator is set up at the anode location one would naturally obtain all the data pertaining to this current flow without moving the generator. This is also true at the current setup for the crossing.

Also, it is evident that if the foreign line is to receive some cathodic protection, the bond current will be increased enough so that it more than overcomes the discharge due to the anode current. In this case polarization data may be needed on the foreign line as a function of the bond current.

Let us follow the outline above and detail the steps:

(1) If the anode A is very remote from the crossing C on a line such as CZ in Fig. 3, our line will be negative to the foreign line and the latter will probably discharge current at the crossing. If the anode A is brought quite close to the crossing C, it will raise the potential of the earth so as to cause the foreign line to pick up current at the crossing. These conditions are illustrated by Figs. 4 and 5, respectively.

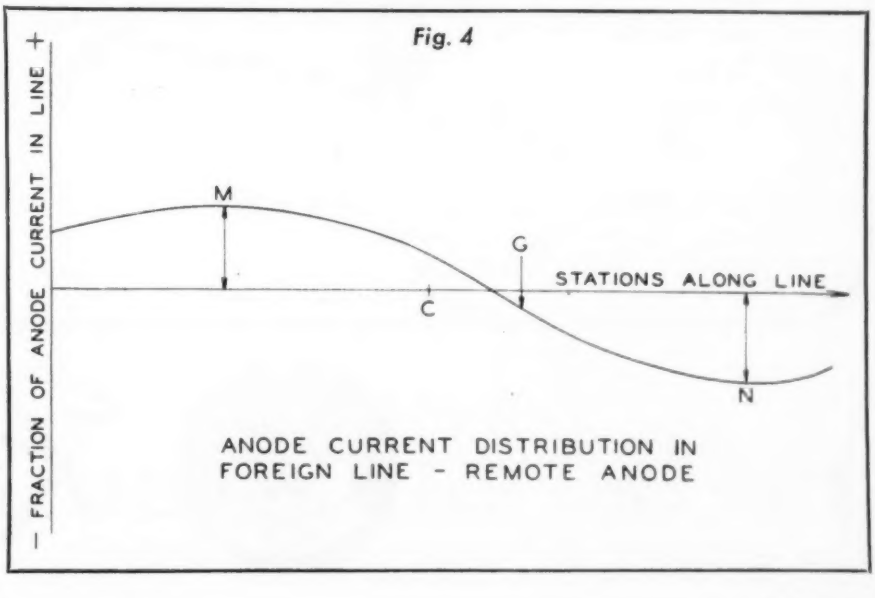
It is apparent that the anode can be located somewhere between the extremes so that there will be neither discharge nor pick-up at the crossing. The conditions at the crossing, however, are not the whole story.

Referring to the above illustrations in each figure are located the current maxima at points M and N. The amount of current discharged in Fig. 4 is the algebraic difference of the currents at M and N, and the discharge area lies between them. In Fig. 5 the algebraic difference of the maxima at M and N is the current pick-up, which is perforce equal to the current loss due to the anode. Here the discharge area lies outside the region between M and N. The optimum location of the anode A is that one for which the difference of the maxima M and N is a minimum. In practice it is better to compromise on the side of the distribution of Fig. 4 than otherwise. This is true because the discharge area is then near the bond where the distribution of bond current is most favorable to remedy the discharge.

In the preliminary examination it is fastest just to locate the points M and N to determine the maximum ampere-hour losses due to the anode current.

(Continued on Page 222)

Fig. 4



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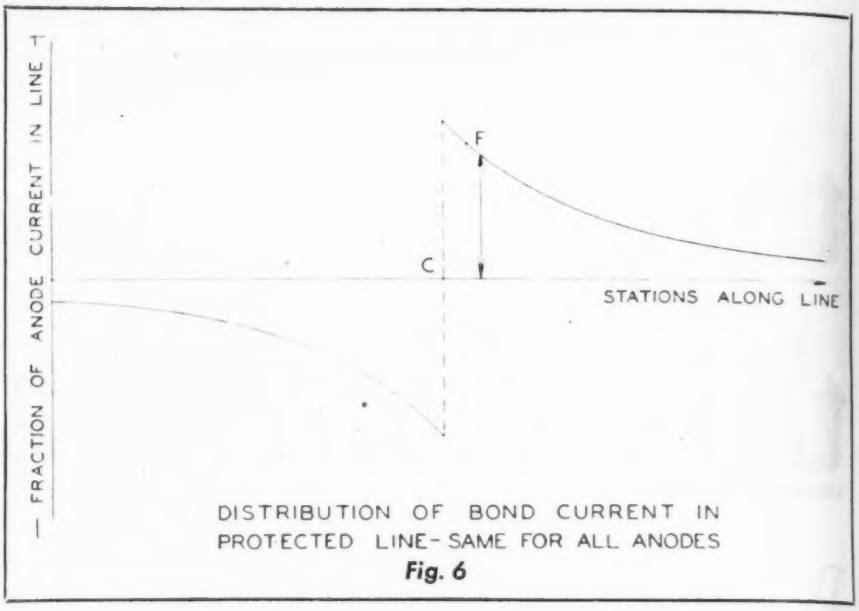
(Continued from Page 219)

This can be quickly done in view of the following: At the points M and N the line current is maximum, and hence there is no pick-up nor discharge of any part of the anode current. For this reason the coupling resistance to earth for anode current is zero. Thus in Fig. 5, for example, at the point N no change in earth potential is observed when varying the anode current. In the positive direction from N along the line, $R_{2,1}$ becomes negative in proportion to the slope of the curve, and in the negative direction from N it becomes positive. Thus the current maxima can be quickly located by finding the zero-coupling points, and the total current discharged is measured as the algebraic difference of the currents at these points. Proceeding this way for each of several feasible anode locations will soon show which location is best.

(2) Having chosen the anode location, the current requirements are determined by running polarization curves by the null method described above, or by any other method that eliminates the errors due to IR drop effects. The foregoing discussion deals with the details of this type of measurement.

(3) The distribution of anode current in the foreign structure is measured by the method of increments described above. The anode current is built up to a given value, then interrupted. The number of amperes interrupted is the change in anode current. At the same time, a calibrated set-up is used to observe the change of line current at the chosen place. As the currents are superposed, the change observed is due to the anode current only. The ratio of the change of line current in amperes to the amount of anode current interrupted is the fraction of the anode current that is flowing in the line at that point. A number of determinations of the fraction of the anode current appearing in the line at different points are needed to plot a good curve showing the overall distribution of the anode current. In plotting the curve, the fraction of the anode current observed at each point is given the sign that indicates the direction of flow of the component of the anode current.



DISTRIBUTION OF BOND CURRENT IN PROTECTED LINE - SAME FOR ALL ANODES

Fig. 6

A typical curve is shown in Fig. 4. When this curve is examined, it is found to be steepest at the point marked G (not necessarily at the crossing C). This is the location at which the anode produces the densest discharge of current from the foreign line. (If the anode-current distribution is as in Fig. 5, two steep discharge areas are to be considered.)

(4) In the region G in Fig. 3, located as in step (3), (Fig. 4), are placed permanent ground stakes typified by the single one illustrated by terminals 2 in Fig. 3. Permanent grounds can consist of iron pins driven over or close beside the line. These terminals should be permanent for use for all coupling measurements so that consistency of the data will not be affected by taking the connections first at one point, then another, when correlations must be exact. Iron pins can be used instead of non-polarizing cells because only increments are used, and the potential of the pin itself is canceled out.

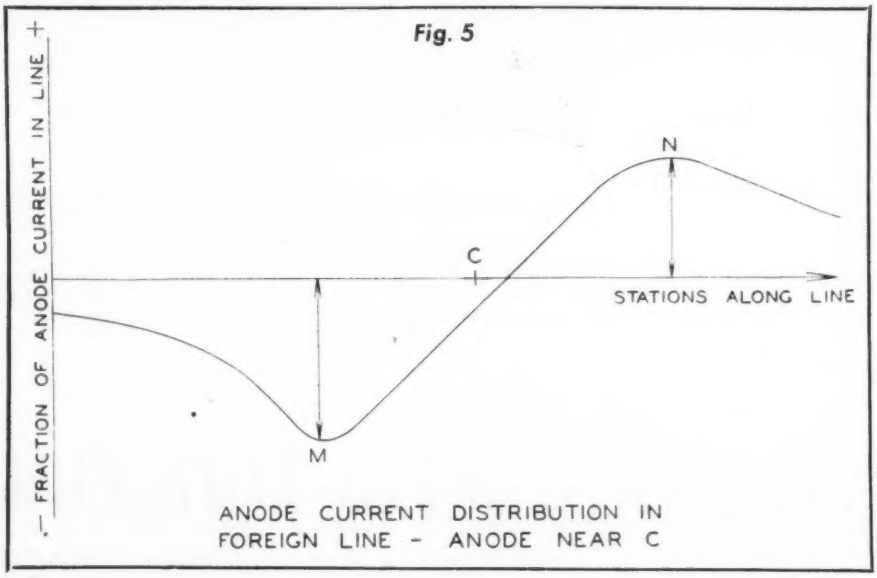
It is interesting to note that the increments of voltage observed with changes of current at other terminals are really the increments of IR drop produced by the current density to the line as a result of the current flow. By having the ground terminals close to the line, the current flow lines are radial, and the current density from one source follows substantially the same paths near the line as the current density from another source. Thus the couplings observed represent a true comparison of the relative current densities.

It is of paramount importance to correct the potential readings made to an iron ground-pin for the resistance of the pin and the leads to the voltmeter. The resistance of the pin can vary with moisture, and so can its potential, but the coupling resistances are found to be quite constant so long as the readings are properly corrected to true open-circuit potentials. Corrections should be made each time any voltmeter is used at a pair of terminals.

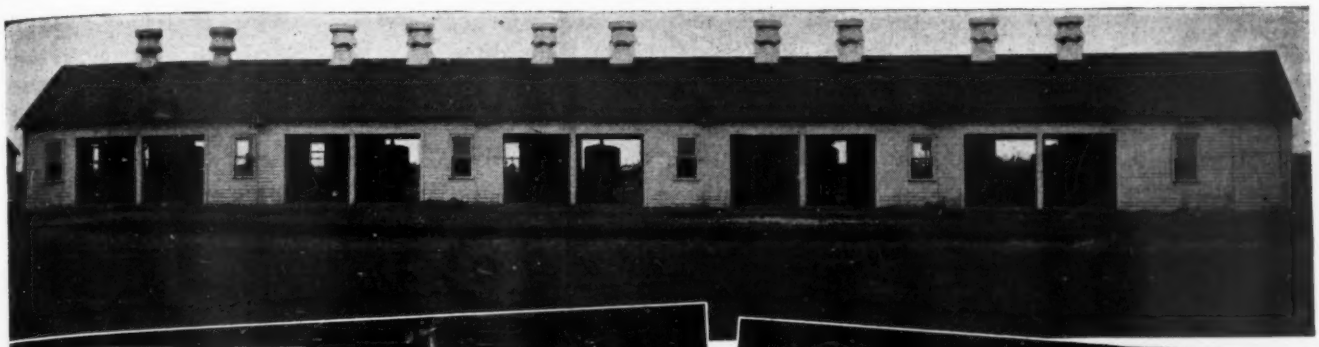
Having located the region G the values of $R_{2,1}$ and $R_{2,B}$ are measured. These are measured by the method of increments by interrupting a measured amount of test current and recording the change in potential at terminals 2, using the proper sign as explained above.

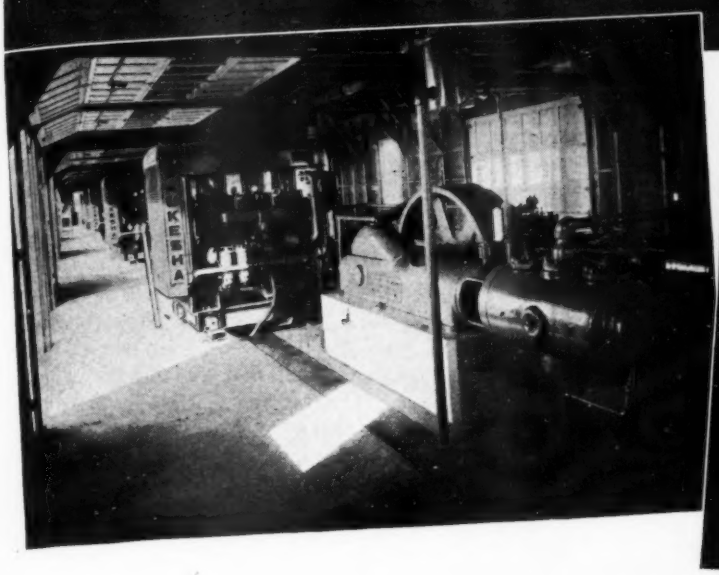
(5) Leaving the anode circuit open, a generator is set up at the bond location B, and the distribution of the bond

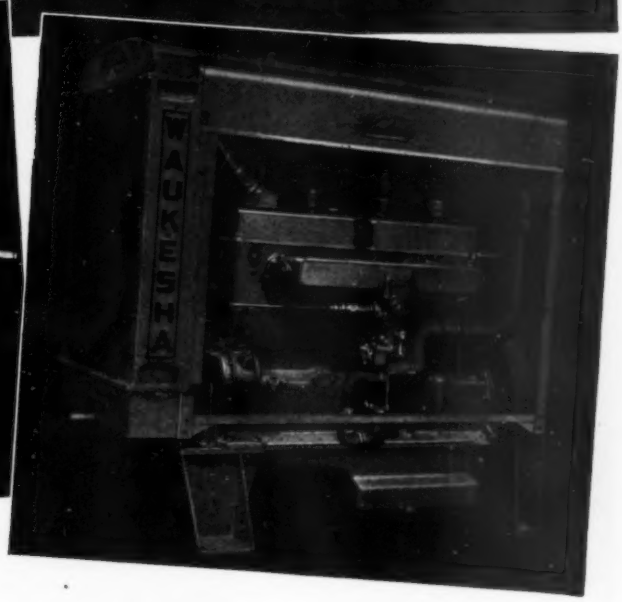
Fig. 5



ANODE CURRENT DISTRIBUTION IN FOREIGN LINE - ANODE NEAR C







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current in the protected line determined. This is done as for the distribution of the anode current in the foreign line. A curve of the distribution, illustrated in Fig. 6, is plotted and the steepest region F located.

In the region F (Fig. 3) several earth terminals are located near the protected structure, typified by terminal 3 as shown. The values of $R_{3,B}$, $R_{3,1}$, $R_{B,B}$ and E_B are measured. E_B is the open circuit P.D. at the bond terminals with no anode current flowing.

(6) The solution of the problem, based on the data, is as follows:

Let I_1 = anode current (to be determined)

I_B = bond current (to be determined)

R_B = bond resistance (to be determined)

The quantities known by measurement are:

E_B = open circuit P.D. at the bond, with no anode current,

$R_{B,B}$ = internal resistance at bond terminals,

$R_{B,1}$ = coupling resistance at B for anode current,

$R_{3,B}$ = coupling resistance to earth in region F of protected structure, for bond current,

$R_{3,1}$ = coupling resistance to earth in region F of protected structure, for anode current,

$R_{2,1}$ = coupling resistance to earth in region G of foreign structure, for anode current,

$R_{2,B}$ = coupling resistance to earth in region G of foreign structure for bond current, and

I_0 = anode current needed to protect the line without a bond at the terminals B.

Because of the way we have chosen the signs for the terminals, all these resistances are positive except for $R_{2,B}$, $R_{3,B}$ and $R_{B,1}$, which will be negative as they represent the discharge of the foreign structure due to the anode, the discharge of the home structure due to the bond current, and because of the choice of signs at the bond.

The solution is arrived at by specifying that:

(A) The pick-up of bond current by the foreign structure shall exactly offset the discharge of anode current at the worst point.

(B) The reduction of cathodic protection current density by the bond current on the home structure shall be made up by a suitable increase of the anode current, at the point where the bond current has the most adverse effect. (F)

The bond current and the bond resistance are related by Ohm's law, so they are not independent, and with one determined the other follows.

These conditions are stated mathematically as follows:

(A) $I_1 R_{2,1} + I_B R_{2,B} = 0$

(B) $I_1 R_{3,1} + I_B R_{3,B} = I_0 R_{3,1}$

Solving for the currents yields:

$$I_1 = + \frac{R_{2,B} R_{3,1}}{R_{3,1} R_{2,B} - R_{2,1} R_{3,B}} \times I_0 \text{ amp.}$$

$$I_B = - \frac{R_{2,1} R_{3,1}}{R_{3,1} R_{2,B} - R_{2,1} R_{3,B}} \times I_0 \text{ amp.}$$

Dividing one by the other gives the ratio:

$$\frac{I_B}{I_1} = - \frac{R_{2,1}}{R_{2,B}}$$

which is the fraction of the anode current that will be represented in the bond current.

It is apparent that if the value of $R_{2,1}$ is too large the denominators in the current-value relations begin to approach zero. When this occurs, there is no solution by use of a bond at the chosen terminals. This condition arises when the anode location is unwisely chosen, and especially so in cases where the foreign structure has high resistance joints.

Having the value of the currents re-

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quired at the bond and anodes, respectively, we need the value of the bond resistance that will pass the required bond current when the anode current is set at its proper value.

This is deduced as follows:

Let E^1_B be the P.D. at the bond terminals when they are open, and the anode current is flowing. As the potentials are superposed:

$$E^1_B = E_B + I_1 R_{B,1}$$

This internal P.D. will cause a current to flow through a bond of R_B ohms resistance, connected across the terminals. As the current will reduce the P.D., it is a negative current, and is expressed as:

$$I_B = -\frac{E_B + I_1 R_{B,1}}{R_{B,B} + R_B}$$

$$\therefore -\frac{E_B + I_1 R_{B,1}}{R_{B,B} + R_B} = -\frac{R_{2,1}}{R_{2,B}} I_1$$

the right hand expression being the ratio derived above between the anode and bond currents.

If E_B were zero I_1 would cancel out of the above expression. This would mean that the value of the bond resistance R_B would be independent of the anode current. This is approximately true for conditions where E_B is very small compared to the P.D. produced by the anode current.

In general E_B is not zero, and it represents the driving force that produces a galvanic current flow between the two structures when they are connected together. As it is in the above expression, it modifies the value of the bond resistance to take account of the current due to the galvanic couple between the two lines. This leads to two requirements for the value of the bond resistance. Because the anode current may be modified in the future, R_B should be adjustable over sufficient range to account for these modifications. Also, the flow of the polarizing current may produce a change in the value of E_B, and the range of adjustment of R_B should take this effect into account.

Solving the right hand equation last above, we find for R_B:

$$R_B = \frac{E_B + I_1 R_{B,1}}{\frac{R_{2,1}}{R_{2,B}} I_1} - R_{B,B} \text{ ohms.}$$

There are a few points that should be noted in actually carrying out the field work. One of these has to do with conditions at the crossing C. In general, if the spacing of the two pipes is equal to or greater than the sum of their diameters, then if one of the pipes is picking up current from the anode near the crossing this will be the case at the crossing. When the spacing is too close, the intervening earth is in effect shielded from the rest of the earth by the metal and acts as a resistance in parallel with the bond. This can lead to electrolysis of the anodic line, and can be controlled simply by insulating one of the lines for 10 or 15 pipe diameters each side of the crossing. Terminals can be introduced between the lines to measure this effect, but it is better to install the insulation if there is any question of the lines being too close.

Having made the installation, the quickest way to check it is to measure the coupling resistance to earth on the foreign structure throughout the erstwhile discharge area. This is done by variation of the anode current, with the bond in place. All couplings must be zero or positive when read as at terminal 2 Fig. 3.

On the protected structure, the couplings will be lower in value where the bond affects them. The check here is that the lower coupling resistance multiplied by the increased anode current must equal or exceed the original protective anode current (no bond) times the original coupling resistance.

In conclusion, these methods will:

(1) Determine the protective current needed for cathodic protection by measuring the cathodic polarization, free from errors due to IR drops.

(2) Provide a practical procedure with which problems of interference or cooperative protection can be solved.

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This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue, 73-79, inclusive, in the January, 1944, issue, and 80-82, inclusive, in the April, 1944, issue.

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Hyatt Bearings Division, General Motors Sales Corporation	(sheet 1)	232	May	P 425.217.001.
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WIRE LINE SERVICE CHART

This chart is for finding wire line service in ton miles for round trips with drill pipe.

Curves are based on formula: T.M. = $\frac{WL\,(l + L) + 4ML + 2W_1L}{5280 \times 2000}$

Where: T.M. = ton miles,
W = net weight per foot, including allowances for full hole tool joints and buoyancy of 10-lb. mud,
l = length of stand, 90 ft.,
L = depth of hole, ft.,
M = weight of traveling block assembly, and
W_1 = weight of drill collar assembly.

Example of use of chart. Find ton miles service for round trip at 6000 ft. with 4½-in. O. D., 18.10-lb. drill pipe using a traveling block assembly weighing 14,000 lb. and a drill collar assembly weighing 8000 lb.

1. Start at point 1, 6000-ft. mark on horizontal scale for depth of hole, at bottom of chart.
2. Follow vertical line upward to point 2 at Group A curve for traveling block assembly weighing 14,000 lb. Then follow horizontal line to point 3 in ton miles scale at left of chart and at point 3 read 32 ton miles service on traveling block during the round trip.
3. Return to point 2 and follow vertical line upward to point 4 at Group B curve for drill collar assembly weighing 8000 lb. Then follow horizontal line to point 5 in ton miles scale at left of chart and point 5 read 9 ton miles service on the drill collar during the round trip.
4. Return to point 4 and follow vertical line upward to point 6 at Group C curve for 4½-in. drill pipe. Then follow horizontal line to point 7 in ton miles scale at left of chart and at point 7 read 57 ton miles service on the drill pipe during the round trip.
5. Total ton miles wire line service during trip equals sum of ton miles found at points 3, 5, and 7 or 32 + 9 + 57 = 98 ton miles total (answer).

The following table may be used for finding ton miles for 4½-in. O.D. drill pipe at depths less than 2000 ft.

Depth, ft.	Ton Miles 16.60 lb.	18.10 lb.	Depth, ft.	Ton Miles 16.60 lb.	18.10 lb.
100	0.7	0.7	1100	9.1	9.3
200	1.4	1.4	1200	10.1	10.4
300	2.2	2.2	1300	11.1	11.4
400	2.9	2.9	1400	12.2	12.5
500	3.7	3.8	1500	13.3	13.6
600	4.5	4.6	1600	14.4	14.8
700	5.4	5.5	1700	15.5	16.0
800	6.3	6.4	1800	16.7	17.2
900	7.2	7.3	1900	18.0	18.4
1000	8.1	8.3	2000	19.1	19.7

Divide above values or values from curves by 2 for ton miles in a half-round trip.

For estimating weight of drill collar assembly, use following table and add weight of bit and reamer:

O.D., in.	I.D., in.	Wt. ft., lb.	O.D., in.	I.D., in.	Wt. ft., lb.
8	3-13/16	132	6-1/4	3	80
8	3-1/2	138	5-3/4	2-1/4	75
7	3-1/2	98	4-5/8	2-9/16	40 120
7	3	107	3-7/8	1-3/4	32
			3-1/4	1	26

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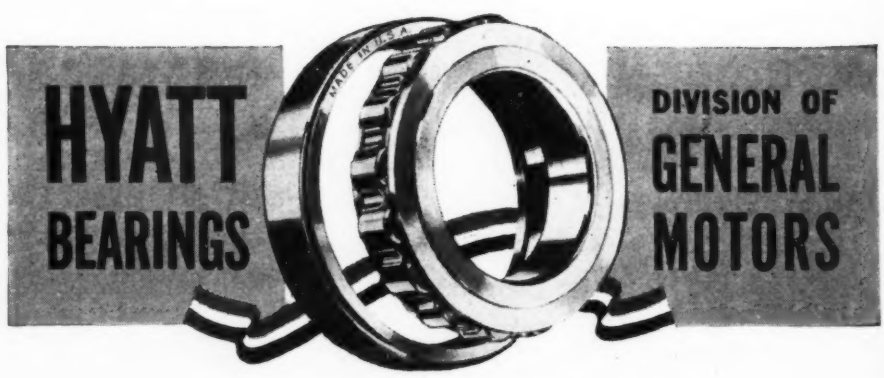

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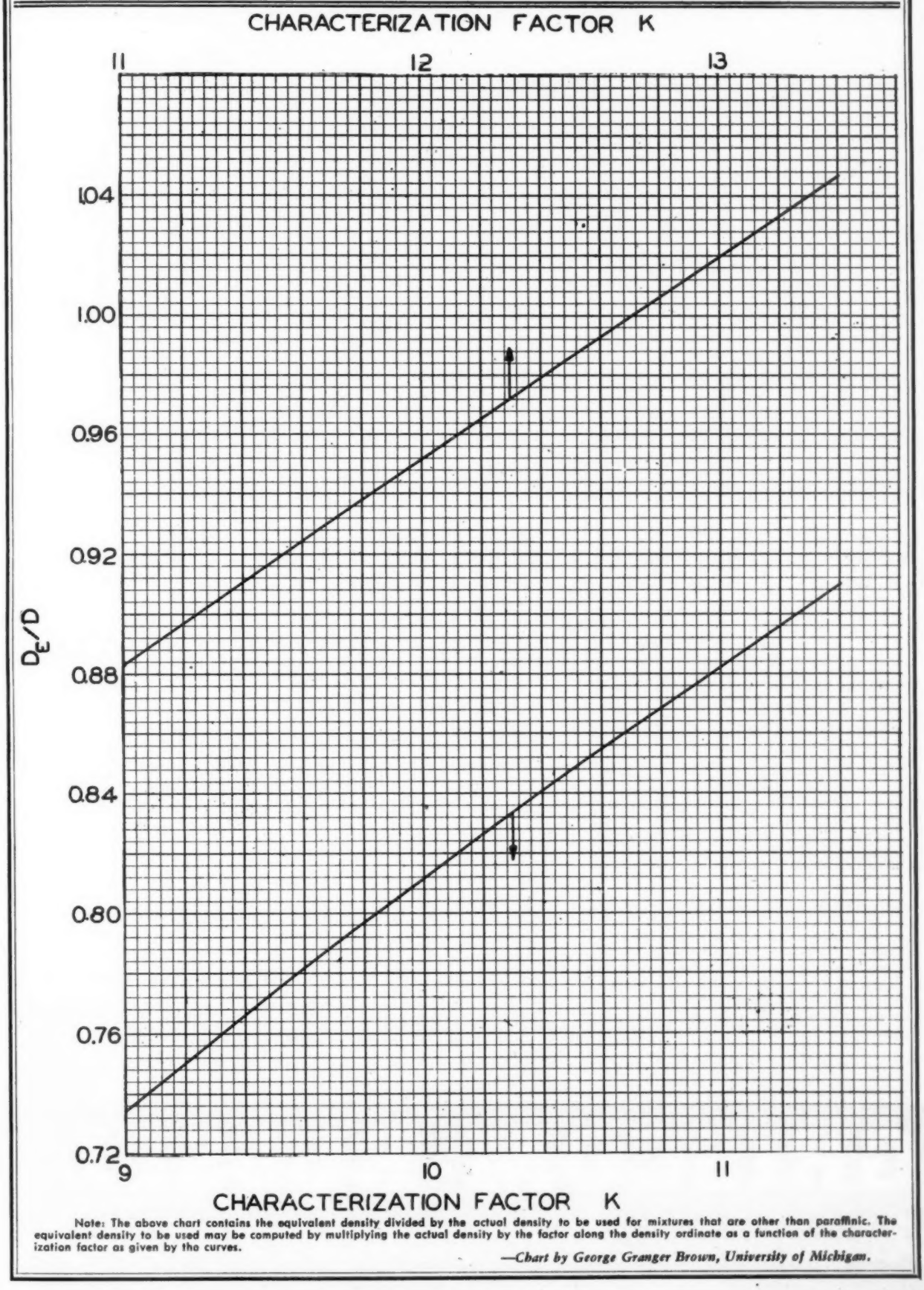
RATIO OF DENSITIES AS A FUNCTION OF CHARACTERIZATION FACTOR



Note: The above chart contains the equivalent density divided by the actual density to be used for mixtures that are other than paraffinic. The equivalent density to be used may be computed by multiplying the actual density by the factor along the density ordinate as a function of the characterization factor as given by the curves.

—Chart by George Granger Brown, University of Michigan.

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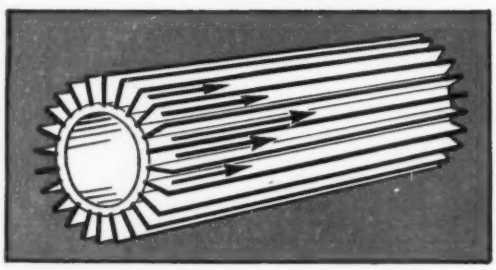

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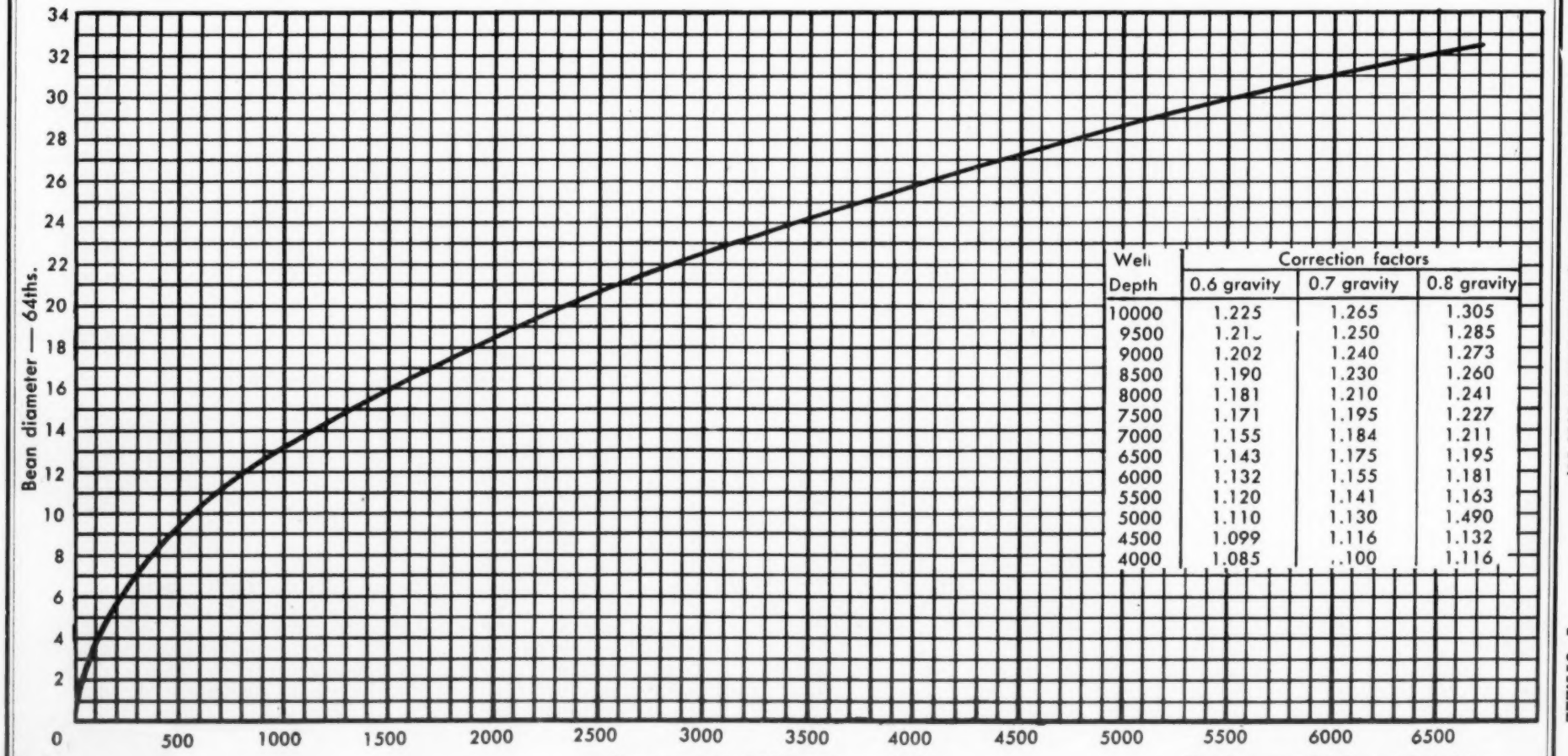
In preparing the corrections average surface readings from 500 lb. to 4000 lb. per sq. in. were used. Using Bureau of Mines Monograph 7 meant extending the tables for both depth and pressure.

Curve is based on conditions where ratio of tubing pressure above bean to pressure below is less than 0.5, assuming 1000 lb. per sq. in. as lower pressure on this curve.



Well Depth	Correction factors		
	0.6 gravity	0.7 gravity	0.8 gravity
10000	1.225	1.265	1.305
9500	1.21.	1.250	1.285
9000	1.202	1.240	1.273
8500	1.190	1.230	1.260
8000	1.181	1.210	1.241
7500	1.171	1.195	1.227
7000	1.155	1.184	1.211
6500	1.143	1.175	1.195
6000	1.132	1.155	1.181
5500	1.120	1.141	1.163
5000	1.110	1.130	1.490
4500	1.099	1.116	1.132
4000	1.085	..100	1.116

Chart by courtesy Otis Pressure Control, Inc.

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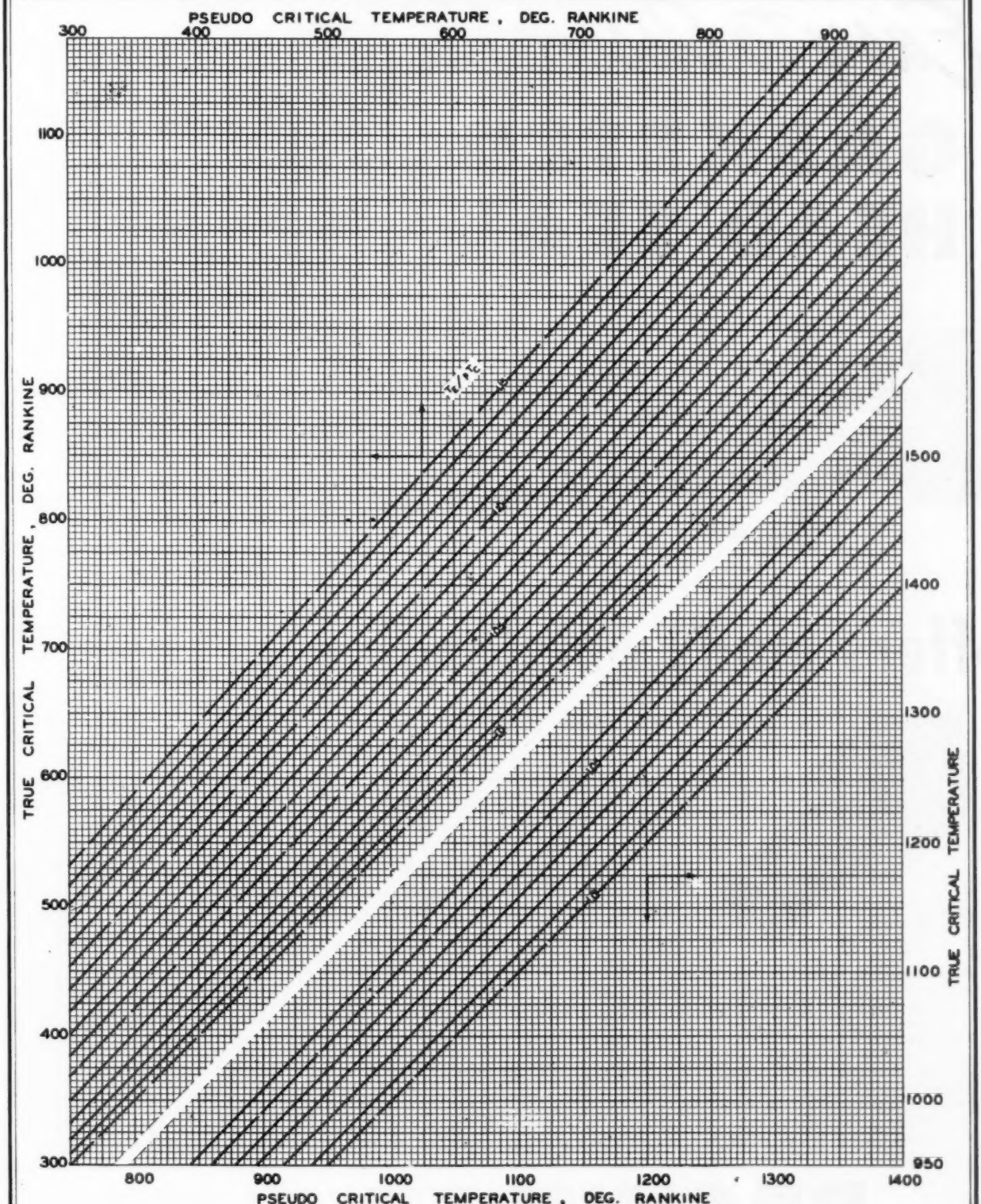
TA-1284

THE CRITICAL TEMPERATURE OF A HYDROCARBON MIXTURE



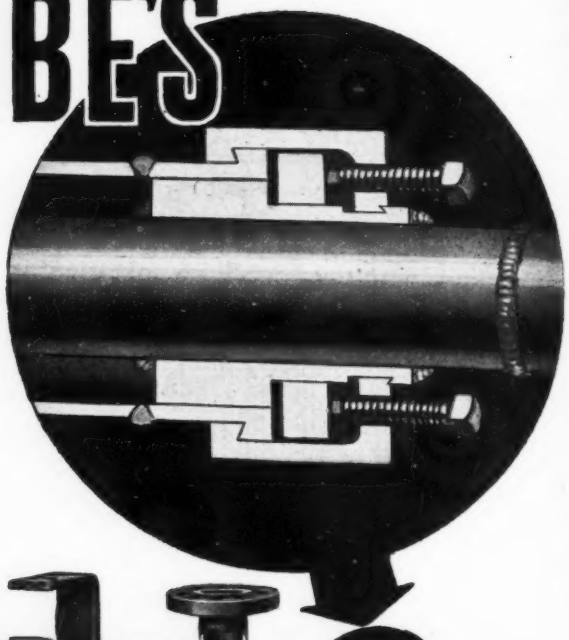
Note: This chart contains the critical temperature of hydrocarbon mixture as a function of pseudo critical temperature and the computed or the correct ratio of equivalent critical temperature to pseudo critical temperature.

—Chart by George Granger Brown, University of Michigan.

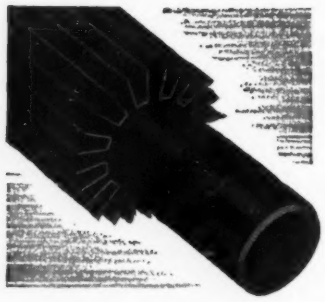
BROWN FINTUBE'S

Easy to Assemble

GASKETED HEAD SEAL



offers many outstanding advantages



Brown Integrally-Bonded Fintubes are used in all Brown Fintube Heat Exchangers,— are available in Exchangers made by most other manufacturers,— and are ideally suited for many other heating and cooling services. Furnished in plain, "longitudinal," or "cut and twisted" types,— wide range of sizes in low-carbon or special steels. Design assistance furnished gladly.

★ Consisting of two split collars, provided with cap screws, which can be tightened to force the solid ring and gasket against the shoulders of "positioning fittings" welded on the shell and fintube – (see view above),– the new head seal on Brown Fintube Sectional Heat Exchangers has won enthusiastic acclaim from operating and maintenance men.

This new seal is easily assembled and disassembled with only a small movement of the cap screws–and using a standard wrench–thus permitting the exchanger sections to be mounted side by side–saving space. It avoids lapped, gland, or ground joints–and since all parts are easily accessible for cleaning, the seal assures positive, tight closure–time after time–free from dirt–and without any outboard stress, or any torsional twisting of either the shell or fintube. The seal holds exceedingly high pressures without "bleeding"– can be used with either composition or metallic gaskets,– and offers many other advantages. But send for Bulletin No. 432. It gives full details about Brown Fintube Sectional Heat Exchangers,– gives dimensions of standard units,– and contains other data of much interest to engineers and operating men.

THE BROWN FINTUBE CO.

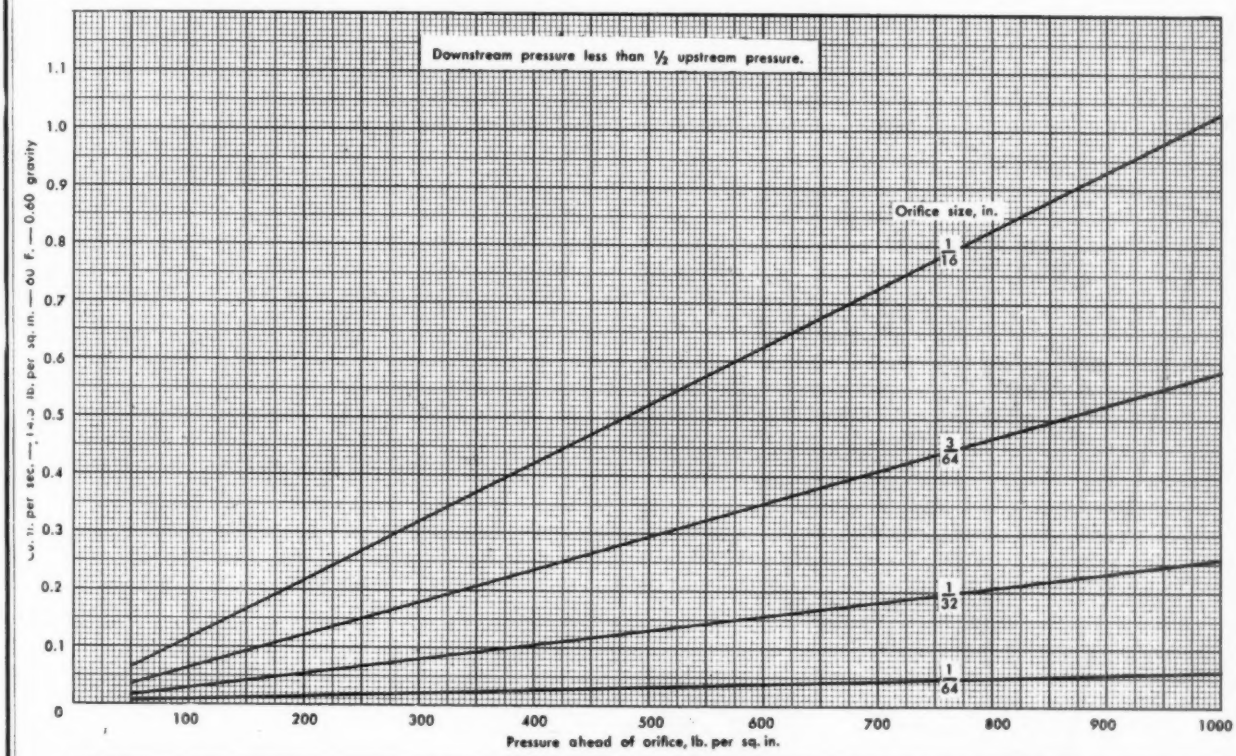
125 FILBERT STREET • ELYRIA, OHIO

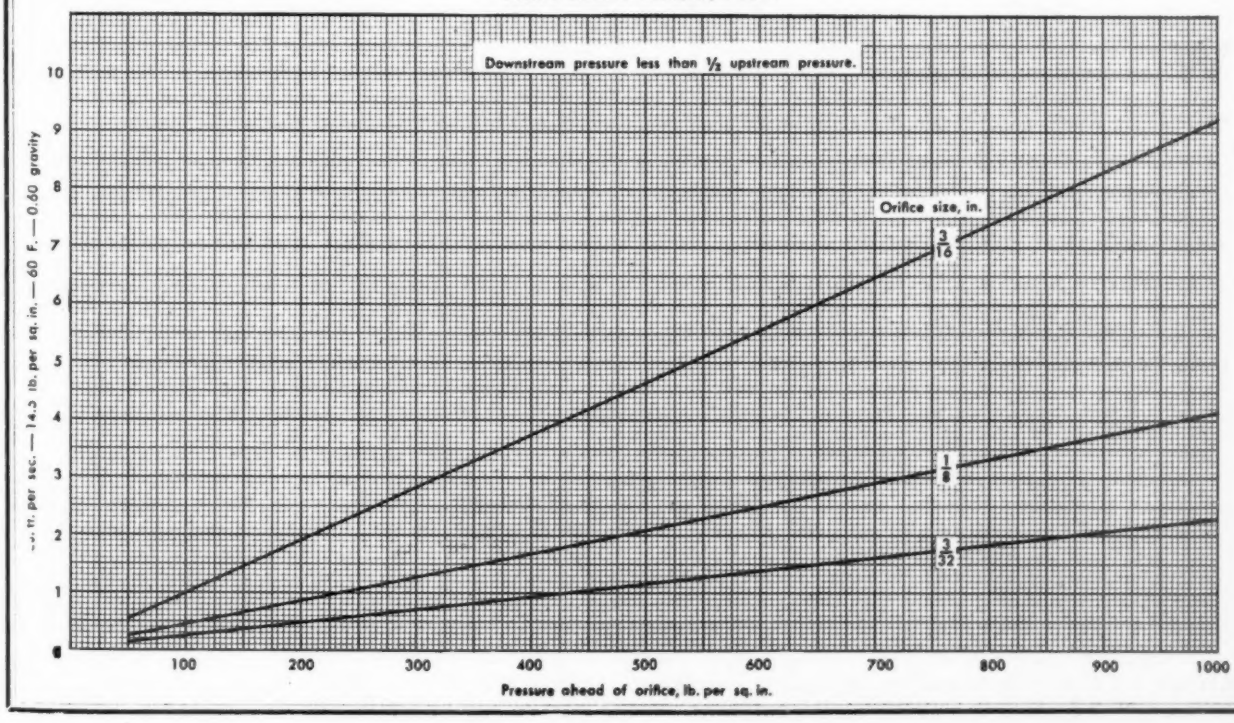
MANUFACTURERS OF INTEGRALLY BONDED FINTUBES AND FINTUBE HEAT EXCHANGERS

GAS FLOW THROUGH ORIFICES

These curves were designed primarily to be used in calculating the volume of gas that would flow through various size orifices, where the downstream pressure is less than one-half upstream pressure. The formula used is $Q = C\sqrt{HP}$.

Principally use is for estimating the volume of gas that will flow through holes in tubing for gas-lifting a well. Aeration of the fluid column in the tubing in producing the well will be controlled by the gas injected into it through the orifice or holes in the tubing. The differential pressure between the gas in the casing and that of the total gas and fluid in the tubing will vary in proportion to the depth of the well. The capacity of any orifice under back pressure will be controlled by the differential pressure existing across the orifice. The usual limits of the downstream pressure will be 50 per cent less than the upstream pressure. On this basis the volumes of these orifices were calculated, they have been a convenient method in deciding on the size orifice to select in accordance with the depth of the well.





Because Oil is Ammunition . . .

Wherever men and planes and ships go — oil must go with them. Oil must fight on every front, on every sea. And to get it there — and keep it there — calls for the surest safeguards that can be put on drums.

Tri-Sure Closures answer that demand — with a *seal*, *plug* and *flange* that form *three* lines of defense against every hazard, a *triple* safeguard that keeps every drop of oil inside a drum and every drop of water *out*.

Look at the cross-section view of a Tri-Sure Closure shown above. There you will see the fortress of safety that this *triple* protection forms. And you will see why, on battlefronts thousands of miles away, oil is arriving "as shipped" — in Tri-Sure fitted drums.

Tri-Sure
Reg. U. S. Pat. Off.
CLOSURES

AMERICAN FLANGE & MANUFACTURING CO. INC., 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.
TRI-SURE PRODUCTS LIMITED, ST. CATHARINES, ONTARIO, CANADA

WIRE LINE SERVICE CHART

This chart is for finding wire line service in ton miles for half round trips with casing and tubing.

The chart was constructed from the formula: T. M. $= \frac{WL^2 - 4\,ML}{2 \times 5280 \times 2000}$

Where: T. M. = ton miles,

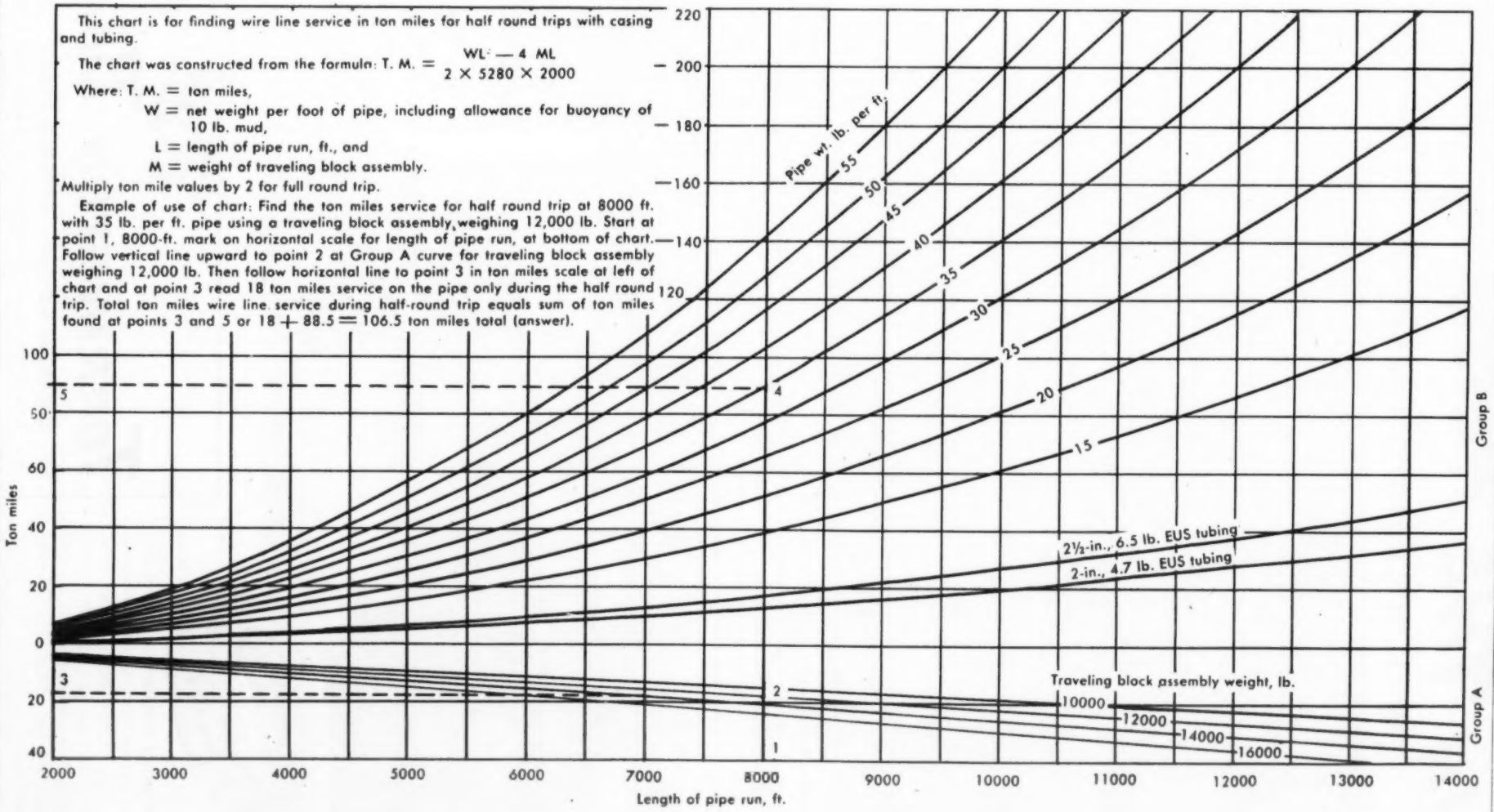
W = net weight per foot of pipe, including allowance for buoyancy of 10 lb. mud,

L = length of pipe run, ft., and

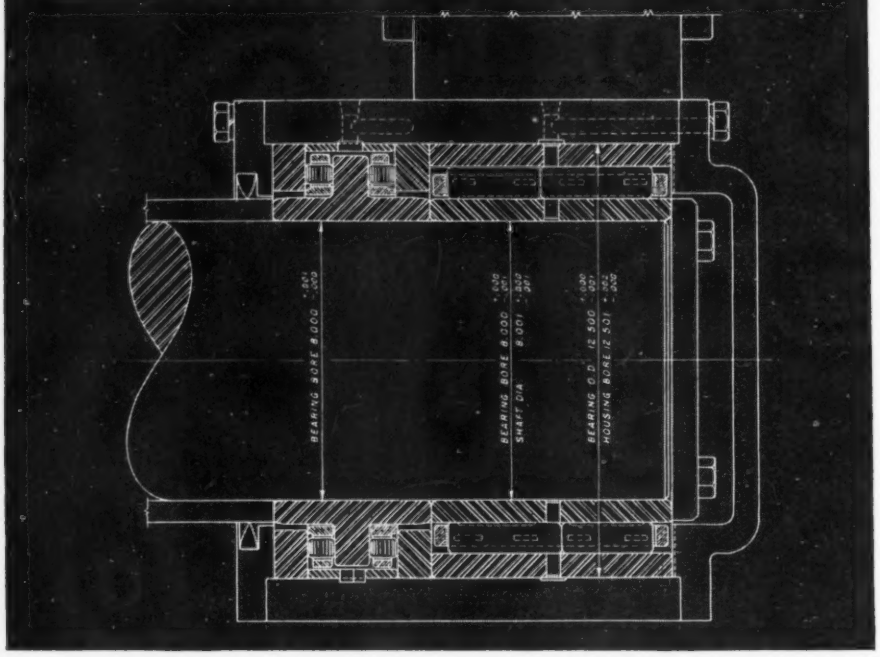
M = weight of traveling block assembly.

Multiply ton mile values by 2 for full round trip.

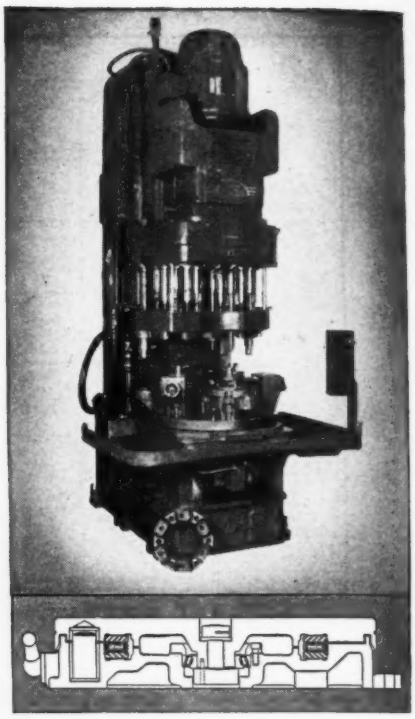
Example of use of chart: Find the ton miles service for half round trip at 8000 ft. with 35 lb. per ft. pipe using a traveling block assembly weighing 12,000 lb. Start at point 1, 8000-ft. mark on horizontal scale for length of pipe run, at bottom of chart. Follow vertical line upward to point 2 at Group A curve for traveling block assembly weighing 12,000 lb. Then follow horizontal line to point 3 in ton miles scale at left of chart and at point 3 read 18 ton miles service on the pipe only during the half round trip. Total ton miles wire line service during half-round trip equals sum of ton miles found at points 3 and 5 or 18 + 88.5 = 106.5 ton miles total (answer).



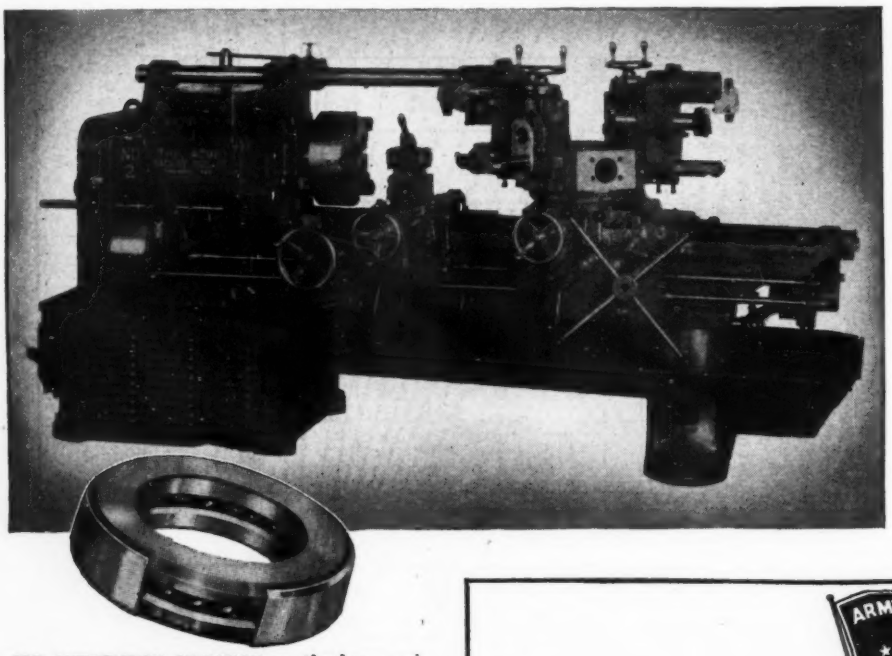
IN THE NEWS
WITH TORRINGTON BEARINGS



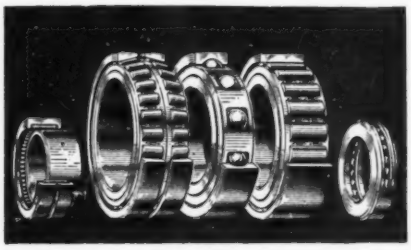
270,000 POUNDS RADIAL LOAD and 168,000 pounds thrust load is the capacity of this compact, 12.5" O.D. Torrington Mill Type Bearing designed by the Company's Bantam Bearings Division to carry the work rolls of a new design axle-type rolling mill in the steel industry. This is another interesting example of the ability of Torrington engineers to design and build anti-friction bearings to meet new and specialized requirements.



MULTIPLE STATION DRILL PRESS, built by Snyder Tool & Engineering Company, uses large Torrington Roller Thrust Bearings to provide anti-friction operation for the rotary table and insure sturdy support to the "work." Bearing, as shown in cross-section, is supplied in three sizes to meet the requirements for both hand and power indexed tables.



FOR ANTI-FRICTION OPERATION on the long and cross feed shafts of this Universal "Cincinnati Acme" Turret Lathe, built by The Acme Machine Tool Company, four Torrington banded Ball Thrust Bearings are employed in each apron. This type of Ball Thrust Bearing as shown in inset is supplied by Torrington's Bantam Bearings Division in a standard range of sizes from ½" to 3½" I.D.



THE COMPLETE TORRINGTON-BANTAM LINE includes every major type of anti-friction bearing—straight roller, tapered roller, Needle and Ball. You will find the experienced assistance of Torrington engineers helpful in selecting the *right* bearing for any anti-friction bearing problem. For today's requirements or assistance in laying out your postwar designs—TURN TO TORRINGTON!

ARMY E NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

HEAT TRANSMISSION THROUGH FURNACE WALLS

Directions for Use of Charts

Fig. 3 and Fig. 4 are one component wall charts. Select the chart corresponding to the known K-factor. Find the known hot-face temperature on the left hand vertical scale and move across the chart to the given wall thickness. The cold-face temperature may be read directly from the lower scale and the heat loss in B.t.u. per hr. per sq. ft. on the upper scale.

The dashed line curves on the chart are for standard thickness of brick walls. Solid curves may be used for selection of proper wall thicknesses when materials such as refractory concrete are used and the designer is not limited by standard size units.

The curves in the charts are plotted in terms of conductivity factors (K) in order to make them adaptable to any of the materials commonly used in the construction of most industrial furnaces. This arrangement also permits the use of more accurate conductivity data that may later be developed for specific materials.

Formulas and material for calculation of the charts was obtained from "Recommended Procedure for Calculating Heat Losses Through Furnace Walls," Manual of American Society for Testing Materials Standards on Refractory Materials. All temperatures are in degrees Fahrenheit. The outside surface of furnace wall is considered as exposed refractory or steel jacket, with an ambient atmosphere of still air at 80°F.

Conductivity Chart

The conductivity chart at the right shows the relation of the conductivity of clay firebrick and concrete made using crushed firebrick as the aggregate. In crushing the brick to aggregate sizes and recombining the grog in granular form from 10 per cent to 15 per cent of the density is lost. This results in a lower conductivity for the Refractory Concrete.

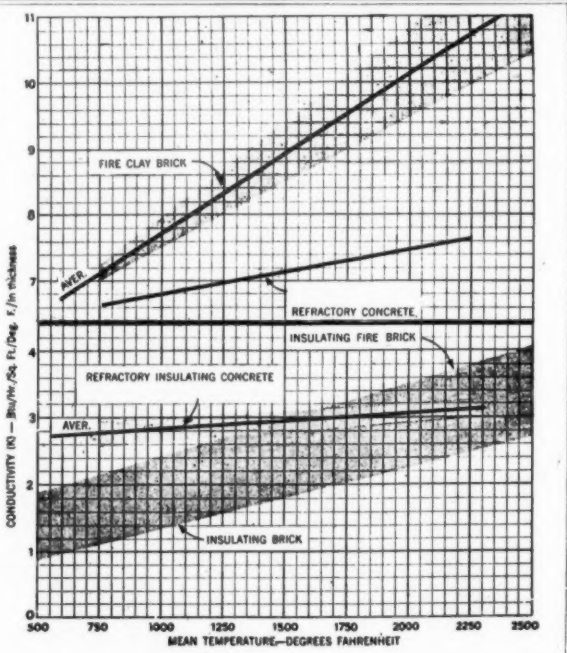


Fig. 4. Wall of one component, K = 3.5

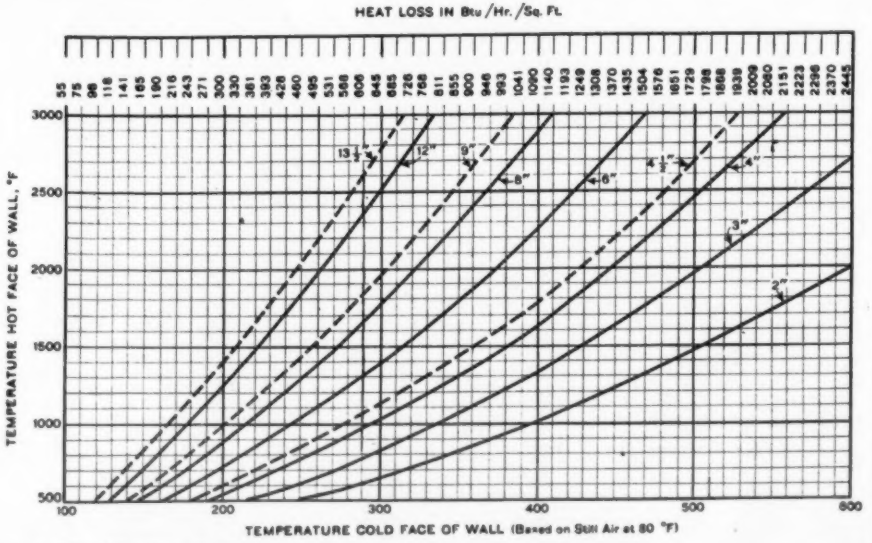
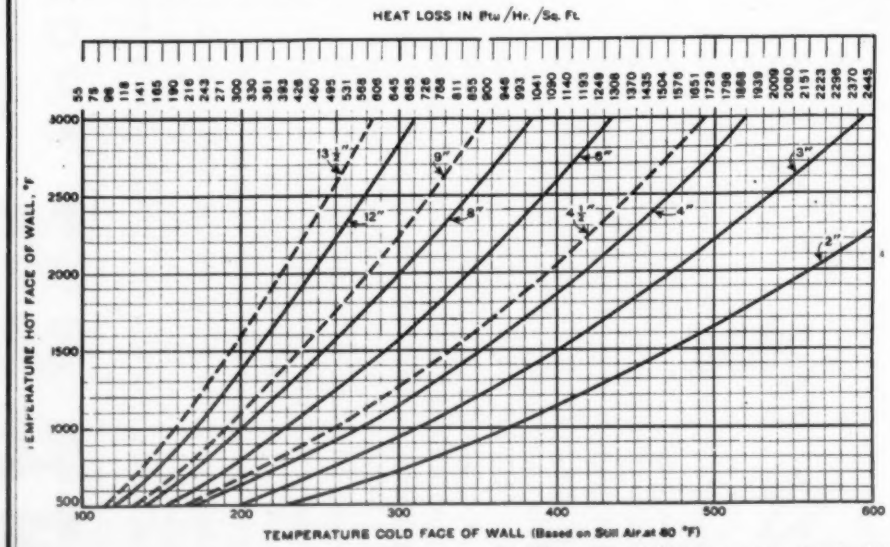


Fig. 3. Wall of one component, K = 3.0



This series of tables by courtesy of copyright owner, The Atlas Lumnite Cement Company.

This Simple Compressor Meets the Complex Needs of a Changing Petroleum Industry

It's the Nash!

Here is a compressor presenting advantages found in no other device. Nash Compressors have only one moving part, rotating without metallic contact with the pump casing. No internal lubrication is required. Yet they produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure.

There are no valves, gears, pistons, sliding vanes, or other complicated wearing parts in a Nash. Compression is secured by an entirely different principle of operation. Because of this, gas pumping problems difficult with ordinary pumps are often easily handled by the Nash. For example, Nash Pumps are standard equipment in the Synthetic Rubber Industry, where they have met the needs of new and difficult processes.

Nash Compressors are compact and save space. They run without vibration, and compression is without pulsation. They maintain original performance over long periods. Service is assured by a nationwide net-work of Engineering Service offices. Instructive bulletin shows how they operate. Write for it.

One moving part.

No internal wearing parts.

No valves, pistons, or sliding vanes.

No internal lubrication.

Low maintenance.

Slugs of liquid entering pump do no harm.

Non-pulsating pressure.

Saves floor space.

75 pounds in a single stage.

NASH ENGINEERING COMPANY

272 WILSON, SO. NORWALK, CONN.

Air Compressor Auxiliaries

☆ Vitally important to maximum overall output of plant

ALTHOUGH the compressor is the prime unit in any compressed air plant, there are certain auxiliaries to it that are vitally important if the plant is to produce overall maximum results. As a rule, nearly every compressor requires an air receiver of ample size, and, in addition, most compressed air plants should use aftercoolers. An approved and efficient air filter should always be installed in the suction, and also a great many protective instruments in the way of gauges, thermometers, relief valves, suitable drains, etc., should be installed when necessary.

Air Receivers

The air receiver forms an essential part in every compressor installation. It not only absorbs pulsations in the discharge of the compressor but also acts as a reservoir for the storage of compressed air, furnishing some reserve capacity to compensate for instantaneous demands in excess of the compressor capacity. It also acts as a condenser for some of the moisture present in the air or gas as it comes from the compressor, and collects such condensation as may pass the after-cooler, keeping it from entering the distribution system. Receivers are also necessary to supply uniform pressure for governing instruments. If governors are connected to the discharge line the pulsations therein will result in unstable operation.

Obviously, the proper functioning of this accessory is essential to the overall efficiency of the compressor assembly, and any weakness will be revealed in faulty operation of the compressed air plant.

The Compressed Air Institute endorses only air receivers that meet the requirements of the A.S.M.E. code and has standardized on a line of such receivers, in sizes and capacities shown in the accompanying table for discharge pressure up to 125 lb. per sq. in. Relief valves must not be set higher than the pressure stamped on the tank.

Aftercoolers

Aftercoolers are advisable, though not absolutely necessary, in nearly every air compressor installation as a means of removing water and oil vapors by means of condensation. Compressed air or gas contains moisture in some degree, dependent upon the condition of the air taken into the compressor. As the air is compressed, it does not condense its moisture because of the rise in temperature that accompanies compression, and thus it is carried along as a vapor through the receiver and into the pipe line. The temperature of the compressed air declines rapidly in the discharge line due to radiation, resulting in much water being condensed in the line, which, aside from being objectionable in the line for many reasons, is destructive to pneumatic tools or other mechanical equipment in which the air is used.

It is to force this precipitation by lowering the temperature of the air before it enters the discharge line that aftercoolers are employed. They are installed near the compressor to condense the moisture before it has a chance to enter the line, and should be installed with an automatic trap to dispose of the condensation as it occurs.

Aftercoolers are of the shell-and-tube type and of course depend for satisfactory performance upon the use of the coldest water available. Obviously, unless the aftercooler is of liberal size, cooling will be incomplete, which means that the maximum amount of water will not be removed from the air. The importance of installing aftercoolers of proper design and capacity is indicated by the accompanying air reaction chart (Fig. 1).

It will be noted that if 1000 cu. ft. of saturated air is drawn into a com-

A.S.M.E. standard air receivers

Diameter, in.	Length, ft.	Actual compressor capacity for which receiver is suited, cu. ft. free air per min.*	Volume, cu. ft.	Types of opening for cleaning
14	4	60	4½	Openings for inspection and cleaning are required and must meet specifications of A.S.M.E. code for unfired pressure vessels
18	6	95	11	
24	6	185	19	
30	7	305	34	
36	8	450	57	
42	10	640	96	
48	12	1275	151	
54	14	1900	223	
60	14	3000	275	
66	18	4500	428	

*For automatic start-and-stop service, extra large receivers are recommended to avoid starting too frequently.

All receivers up to 42 in. by 10 ft. inclusive have screw openings; 48 in. by 12 ft. and larger have flanged inlet and discharge openings. Vertical receivers must have base to raise them 6 in. above floor to permit hammer test by inspector.

Receivers are furnished complete with safety valves, pressure gauge, hand holes or manhole as required by code, drain valve and nipple, and base for vertical receivers.

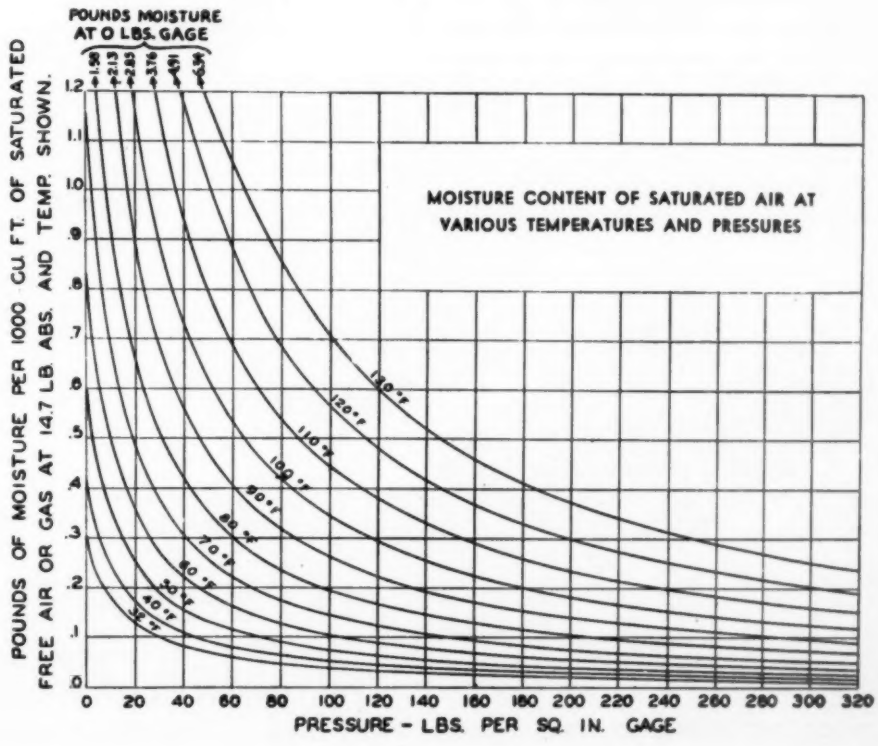
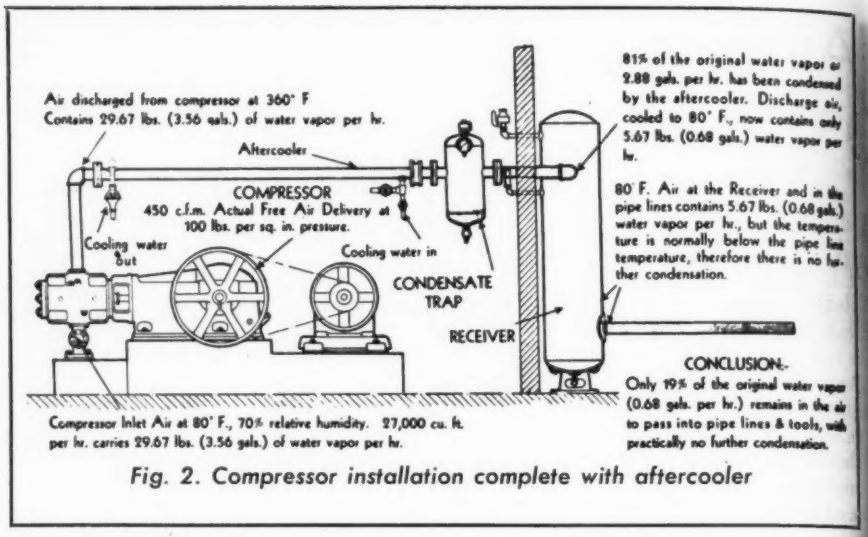


Fig. 1. Weight of moisture per M. cu. ft. of saturated air at various pressures and temperatures

Article by courtesy Compressed Air Institute.

pressor at atmospheric pressure and at a temperature of 70° F., it will contain 1.12 lb. of moisture. Somewhere along the line this moisture will condense and the water pass into any mechanical equipment for which the air is used, causing very rapid wear of these parts. Much loss of time and loss of compressed air is also caused by the necessity for the operator to blow out the air lines each time he uses compressed air for blowing away chips and for similar purposes because of the water present in the line.

Aftercoolers also present an element of safety in every compressor plant. In case any carbon accumulating on the walls of the discharge pipe should become incandescent and start to burn (a condition that might occur with careless operation such as using too much oil of inferior quality and when valve and piston leakage exists) the fire is promptly quenched as soon as it enters the aftercooler and no harm occurs.


Air discharged from compressor at 360° F
Contains 29.67 lbs. (3.56 gals.) of water vapor per hr.
Aftercooler
COMPRESSOR
450 c.f.m. Actual Free Air Delivery at 100 lbs. per sq. in. pressure.
Cooling water Out
Cooling water in
CONDENSATE TRAP
RECEIVER
81% of the original water vapor or 2.88 gals. per hr. has been condensed by the aftercooler. Discharge air, cooled to 80° F., now contains only 5.67 lbs. (0.68 gals.) water vapor per hr.
80° F. Air at the Receiver and in the pipe lines contains 5.67 lbs. (0.68 gals.) water vapor per hr., but the temperature is normally below the pipe line temperature, therefore there is no further condensation.
CONCLUSION:
Only 19% of the original water vapor (0.68 gals. per hr.) remains in the air to pass into pipe lines & tools, with practically no further condensation.
Compressor Inlet Air at 80° F., 70% relative humidity. 27,000 cu. ft. per hr. carries 29.67 lbs. (3.56 gals.) of water vapor per hr.
Fig. 2. Compressor installation complete with aftercooler

Air Filters and Silencers

It is usual practice to run the intake pipe to the outside of the building in order to obtain as cool air as possible. Atmospheric conditions vary, with winds carrying much dust and grit. As a result, the air compressor inlet must be provided with air filters to prevent this dust and grit from passing into the compressor, where is causes rapid wear of the working parts, combining with the lubricating oil as a binder and forming obstructive and abrasive coating on cylinder, valves, etc. The carbon sometimes found on valves, discharge pipe, etc., will be found upon analysis to be mostly dirt with some oil, which can cause leakage by getting under the compressor valves. Such gritty deposit will also add to the rapid wear of moving parts.

The use of filters on the intake can be classed as an element of safety in operation because the elimination of sand will remove one hazard that might produce a spark where operation is sufficiently faulty to cause a combustible mixture to form in the discharge line.

Efficient commercial intake filters have become so standardized and relatively cheap that the earlier method of installing a home-made filter of questionable efficiency is no longer justifiable. The compressor manufacturer best knows what size and type of filter will

BREWSTER Oilbath Slushproof ROTARIES

Full Table Opening
Slush Proof
Alloy Heat Treated Shaft
Gears Heat Treated and Machine Cut
Table Gear Shrunk On—Can Be Replaced When Worn
Gears and Bearings Lubricated in Separate Reservoirs
Ball Bearing Table—Roller Bearing Pinion Shaft
The Last Word in Rotaries

26" for 8000' TO 15,000' DRILLING

22" for 5000' TO 8000' DRILLING

18" for 2000' TO 5000' DRILLING

12" for 1000' TO 2000' DRILLING

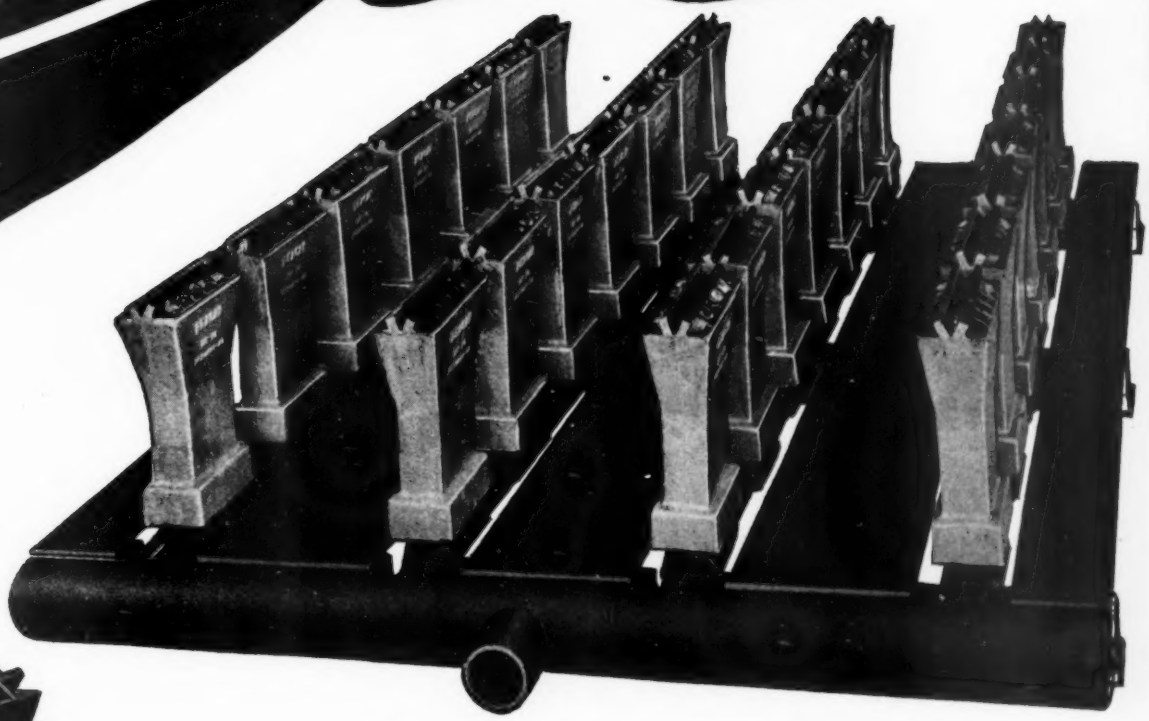
PROMPT DELIVERY

The BREWSTER CO., INC.

SHREVEPORT, LOUISIANA, U.S.A.

FOR EXPORT: Acme Well Supply Co., 19 Rector St., New York City

Hottest BURNER IN THE OIL FIELDS!



Patented V Mantle Spreads Blue Flame Over Entire Fire-Box

HUNT-REAGAN

Improved Low Pressure Gas Burner

Delivers more heat per dollar of fuel cost. Patented V-shaped mantle spreads blue flame throughout entire fire-box. Produces maximum boiler horsepower, with less fuel, and without stack blowers. Installed in 30 minutes . . . cleaned in 5 minutes. Built in all standard boiler sizes. It's the oil country's No. 1 Steam-maker! Full details in your Composite Catalog, or Hunt Catalog.

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FIELD SHOPS:
Houston, Bay City, Corpus Christi, Jennings, Shreveport, Harvey

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HUNT TOOL COMPANY
HOUSTON, TEXAS, U. S. A.

give best service with his compressor with the least pressure drop in the lines. If possible, a suction filter should not cause a pressure drop in the suction line of more than 2 in. of water.

When the noise of the suction is objectionable due to the location of the compressor, an air silencer should be used. Several makes of satisfactory silencers are now readily available and recommendations can be obtained from the compressor manufacturer. The silencer also should not offer excessive resistance to the flow of air.

Discharge silencers are also available when excessive noise is experienced on the discharge, frequently called "tank ring," resulting from discharge pulsations impinging against the air receiver.

Protective Devices

Many protective devices should be installed in every compressed air system. If a shutoff valve is installed in the discharge line, a relief valve must be placed on the compressor side of the valve to protect the machine in case the operator starts the unit before opening the valve. Part of the standard equipment of air receivers is a relief valve but that will not protect the compressor if a shutoff valve is located between the receiver and compressor.

Drains of ample size should be installed wherever needed. Intercoolers and aftercoolers condense considerable moisture that is in the air. This condensate must be carried away and not allowed to pass through the next compressor cylinder. It is good practice to make these drains automatic so that their satisfactory functioning is not dependent upon attention by the operator. Care must be exercised to insure that the automatic trap works.

In many cases, especially on the larger steam and gas engine-driven compressor equipment, an overspeed shutdown is desirable. These machines usually have limiting speed governors as standard equipment whose purpose is to limit the maximum speed of the machines. Should these governors stick for any reason when the machine tries to overspeed, a device can be installed that will function to shut down the compressor. This device can be obtained at a small extra cost if it is not standard equipment on the machine.

For larger equipment, a lube oil failure shutdown is also desirable because on the larger machines oil failure would result in a considerable repair charge. In case of oil failure, the unit is usually shut down automatically, although in certain installations, such as process work, shutdown of the equipment may be very undesirable. In such cases the device could sound an alarm to give the operator warning that there is something wrong with the oiling system.

Jacket water failure shutdown is a protection for the machine in case the operator fails to turn on the cooling water or in case the cooling water supply should fail for any reason. This device is not regularly supplied with compressor equipment but may be obtained at a small additional cost.

If the compressor is installed in an inaccessible location or if the operator can make only daily trips to inspect the machine, it is frequently desirable to add additional protective devices, such as a shutdown from excess pressure in the discharge lines, a shutdown due to excess temperature on the discharge for any reason whatsoever, and, in special operations, it is sometimes thought advisable to install a recording discharge gauge or a recording thermometer to record these operating conditions. The compressor manufacturer will make recommendations for any special features.

—— ☆ ☆ ☆ ——

SEES THINGS THROUGH

. . . No Pampering

TAKING the load as it comes, working without favoring or fussing, sometimes running non-stop for months, Case oilfield engines have earned a name for "seeing things through." Their ability to carry on without pampering comes largely from a habit of building machines a little better than seems necessary. It means not only well-balanced strong points, but freedom from weak points. Back of all is the experience of more than seventy years in building engines for outdoor work.

Case oilfield engines take little care for attendance and maintenance. To get the extra life built into Case engines you may now have, be sure they get that little care regularly. For new pumping power you may need, ask your distributor about specifications and availability. Case oilfield engines are built in 30, 49, and 68 horsepower sizes. They are equipped for liquid or gaseous fuels, or both, as desired. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

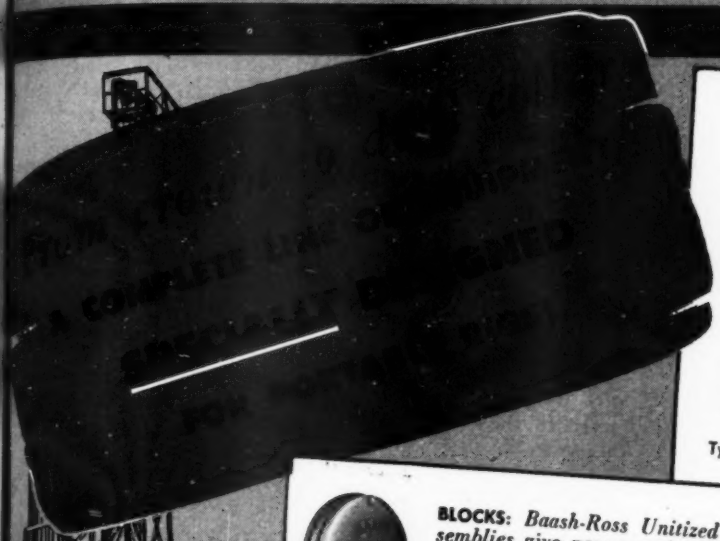
Southwest Equipment Co., Dallas and Kilgore, Texas
Leland Equipment Co., Tulsa, Oklahoma

CASE KEEP ON BUYING WAR BONDS

Baash-Ross News

BAASH-ROSS TOOL COMPANY · LOS ANGELES · HOUSTON · NEW YORK

PETROLEUM ENGINEER EDITION



Type DCO

Type DCS

CROWNS: *The Baash-Ross Crown Blocks for Portable Rigs* incorporate unique advancements specially keyed to portable rig requirements. Extremely compact and rugged, these "in-line" Crowns permit simple over-and-over line reaving, insuring *straight* block travel—a BIG advantage in cramped portable masts.

Two types—DCS with all sheaves same size for rigs where fast line is *inside* the mast . . . and DCO with one sheave larger than others for carrying fast line clear of mast for *outside* string-up.

The Crown is built as a unit, installed as a unit, moved as a unit. Assures rigid sheave alignment at all times. *Many other features—get full details!*

Block with Link Adapter

Block with Hook

BLOCKS: *Baash-Ross Unitized Block Assemblies* give new meaning to "compactness." In these Blocks the space wasted by conventional block-plus-hook arrangements is reduced to an absolute minimum by unitizing the block and hook into ONE compact assembly.

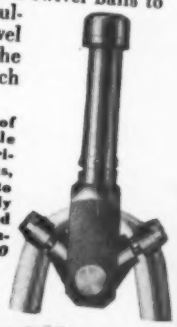
***Two Types*—For maximum compactness the Block with Unitized Link Adapter is recommended. In this unit ears are provided to which elevator links are quickly attached. This, with Swivel Bail Adapter described below, permits drilling, running pipe, etc., all with *one* hook-up. Not only simplifies assembly but also eliminates loose elevators that catch in rigging while drilling!**

For those preferring it, the Block can also be supplied with Unitized Hook as illustrated.

1, 2, 3 and 4 sheave models, capacities 30 to 150 tons—a size for every job!

SWIVEL ADAPTER: To adapt popular makes of portable-rig swivels to the Unitized Block with Link Adapter Assembly described above, the *Baash-Ross Swivel Bail Adapter* is the tool to use.

Readily bolts to standard swivel bails to provide an elevator shoulder for supporting swivel and drill string with the same elevators with which the pipe is handled.



Unique feature is use of quickly interchangeable sleeves to adapt unit to various size elevators. Thus, when changing from large to smaller drill pipe, simply slip in new set of sleeves and Adapter fits the new elevator. *Two sizes—100 and 150 ton!*

BUSHING: The famous *Baash-Ross Roller Kelly Bushing* is available in special sizes to work hand-in-glove with the popular makes of rotary tables used in portable rig work.

This Bushing, already widely used on all standard drilling jobs because of its unusual efficiency, long life and the more accurate bit control it assures, is even more essential for portable operations.

It gives freedom from binding and sudden "feed-offs"—vitally important safeguards on light rigs. And because its unusually smooth feed prolongs life of table bearings, drilling line, swivel bearings and drill pipe, it makes portable equipment last longer, operate more efficiently, require less maintenance!

Type "DU" Slips

SLIPS: The popular *Baash-Ross "DU" Rotary Slips*, so extensively used on standard rigs, are also available in *special* sizes to fit the smaller tables of portable rigs.

These Slips are completely unitized into one compact, easy-to-handle assembly. The sections are hinged together—operate as a unit in gripping the pipe and always set at the same level in the master bushing. Eliminates danger of pipe crimping—a doubly valuable safeguard with the small diameter pipe used on portable rigs!

Drill Collar Slips

Also, the unique *Baash-Ross Drill Collar Slips* are made in special sizes to fit the smaller tables of portable rigs. These are the only slips specially designed to take a full SAFE grip on *all* types of drill collars —new, worn, round or out-of-round.

In contrast to conventional slips which lose their gripping efficiency as the collar wears, Baash-Ross Drill Collar Slips are made up of many small segments, *flexibly* hinged together. As the drill collar wears or becomes out-of-round, the slip assembly *automatically* adjusts itself to maintain perfect fit!

AND . . . still other well-known Baash-Ross products offer the same outstanding advantages on portable as on standard rigs . . . Baash-Ross "Trubore" Kellys (available in shorter lengths for portable work) . . . Baash-Ross "Trubore" Drill Collars . . . Baash-Ross Safety Clamps . . . and many other items.

Make Baash-Ross headquarters for all your portable rig accessory equipment. For full details see your nearby Baash-Ross representative . . . or write direct!

Welded Trailers for Pipe Line Use

PETROLEUM ENGINEER Exclusive Feature

☆ Special trailer designed for service with ditching equipment

ALTHOUGH one of the most prominent advantages of electric arc welding has been its inherent versatility for constructing many kinds of specialized structures and equipment items, the scope of the process has shown constant expansion in all fields of industry.

One significant example is illustrated in oil field work where special trailers of welded design are built for service with ditchers used in pipe-line construction, (Fig. 1).

An interesting factor in this type of welded design consists of the use of tubular members fused to various shapes of plates to reenforce highly stressed points.

The overall length of the trailer illustrated in Fig. 1 is 26 ft. with a 13-ft. bed.

Details of the design shown in Fig. 2 indicate the sections of the structure that are subjected to unusual stress. To provide a durable, non-yielding framework at these points, lengths of 5-in. hydraulic pipe were butt-welded into an "S" shape and welded to the heavy I-beam shown at the right in Fig. 2, and to the tubular section at the base of the body.

Reenforcements were provided at critical stress points by fillet welding ½-in. and 1-in. plate directly to the main tubular sections as shown.

A means by which the trailer rigging can be uncoupled from the trailer body was provided by fitting the 5-in. pipe into 6-in. pipe sections, 4 ft. in length. A pin is fitted through the connection to provide for disengagement.

Further reenforcement at the bottom portion of the tubular joint is effected with a solid 4¾-in. round bar, 18 in. in length, welded to the 5-in. pipe.

The all welded design includes 10-in. side channels for the frame, with two 10-in. I-beams running the length of the bed, and side brackets welded to the top of the frame for holding the wooden uprights of the trailer body. The trailers are a product of the Greggton Parts Shop, Greggton, Texas.

Another example of welding applied in trailer construction is a power take-off clutch for operating trailer dump mechanism built by the Carlisle Bottom Dump Trailer Company of Longview, Texas. Made entirely of standard steel shapes and machined parts, the clutch is 15 in. long.

The component parts (Fig. 3) consist of a cable drum having a 4-in. diameter pipe for the core to which a section of 8-in. pipe is welded all around at one end with a collar at the opposite end.

The drive shaft (Fig. 3, right) is 1⅛-in. in diameter and is welded to stock-sized sprocket. Bearings shown at left and right in foreground (Fig. 3) are constructed by welding a length of ¼-in. pipe on each side to a piece of flat stock.

——— ☆ ☆ ☆ ———

Fig. 1 (Upper left)—Oil field trailer of welded design

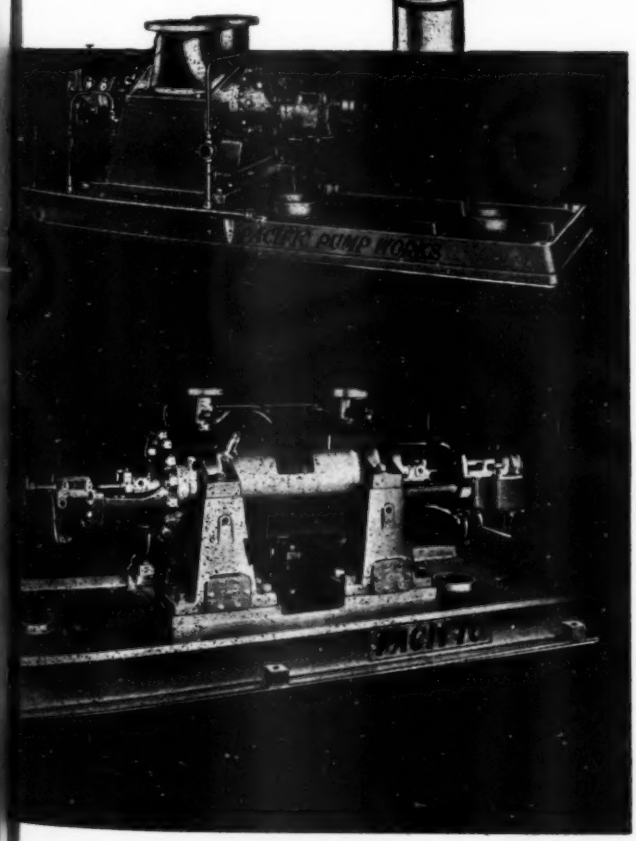
Fig. 2 (Lower left)—Welded plates at critical points provide strength

Fig. 3 (Below)—Component parts of welded clutch

PACIFIC takes it!

FROM SUB-ZERO TO 850 DEGREES

and that's punishment



THINK OF IT! Centrifugal pumps with discs whirling at 3500 revolutions per minute within a third of a hair's breadth of scraping the housing. That's *precision!* Then pour oil or other liquids of 850 degrees against those discs without expanding and jamming the works. Sounds impossible, doesn't it?

Yet, PACIFIC Engineers did it! They introduced chrome alloy steel in radically new designs and worked out a revolutionary cooling system. Result—pumps that perform with precision, not only at 850 degrees, but also at sub-zero and all the intervening degrees. With long life and economy, too!

That's the kind of punishment Pacific Engineered Pumps are built to take. The tougher the job, the better! And there's a type and size of pump to meet all variables in pumping conditions—oil field, refinery, process, utility, synthetic rubber plants—or what have you?

PACIFIC has the ability and the backing to carry through!

PACIFIC PUMP WORKS

Executive Offices and Plant: Huntington Park, California • *Export Office:* 30 Rockefeller Plaza, New York • *Sales and Service:* Offices in principal cities in the United States • *Affiliated Companies:* Dresser Manufacturing Co., Bradford, Pa.; Clark Bros. Co., Inc., Olean, N. Y.; The Bryant Heater Co., Cleveland, O.; Van der Horst Corp. of America, Cleveland, O., Olean, N. Y.; Bovaird & Seyfang Mfg. Co., Bradford, Pa.; Dresser Manufacturing Co., Ltd., Toronto, Ont., Canada.

PACIFIC *Engineered* PUMPS

Hanlon-Waters Sold

Hanlon - Waters, manufacturer of control instruments for the oil and synthetic rubber fields, has been acquired by interests owning McAlear Manufacturing Company and Climax Engineering Company, and in the future will be operated as a division of the latter group, under continuing Hanlon-Waters management.

McAlear Manufacturing Company, Chicago, is the maker of similar control devices used principally for industrial and heating service.

The two companies will be operated as separate divisions using the full plant facilities of each, it was stated by Edward F. Deacon, Climax president. There will be close collaboration between the engineering and sales staffs, however, and each line will be immediately supplemented by exclusive developments, patents, and features of the other.

McAlear will take over selling and distribution functions of both companies in the industrial, power, processing, marine, and heating fields. Hanlon-Waters will continue to concentrate in the oil field.

The Hanlon-Waters line includes, in addition to automatic control instruments, bolted and welded steel tanks and separators. The company holds large government contracts for portable military pipe lines, which the company's engineers helped to develop.

Climax Engineering Company, Clinton, Iowa, third member of the group, manufactures gas, butane, and diesel engines, electric generating sets, etc., widely used in the oil and power fields.

Acquires New Building

The acquisition of another new factory building is announced by Felt Products Manufacturing Company,

Chicago, makers of gaskets, packings, and other sealing materials.

The new building, which will be an addition to the plant buildings already occupied, is a 2-story structure with 125 ft. on Fulton Street, 200 ft. on Carroll Avenue, and occupying the entire block on Sheldon Street. It contains 55,000 sq. ft. of floor space.

To Build Engines

The Lufkin Foundry and Machine Company, Lufkin, Texas, manufacturers of oil field pumping equipment, by arrangement with Cooper-Bessemer Corporation, will manufacture completely and sell two of the oil field size Cooper-Bessemer engines; the GSC 5½ by 7, 2-cylinder, 2-cycle, 25 to 35-hp., and the GSD 7½ by 9, 2-cylinder, 2-cycle, vertical engine. These engines are of the medium speed class, running from 300 to 600 r.p.m., which are conservative rates established for oil field engines for a long period of time.

The new units will be known as the Lufkin-Cooper-Bessemer and will be sold only by Lufkin's organization and its branches in all parts of the oil producing country and also through Cooper-Bessemer Corporation.

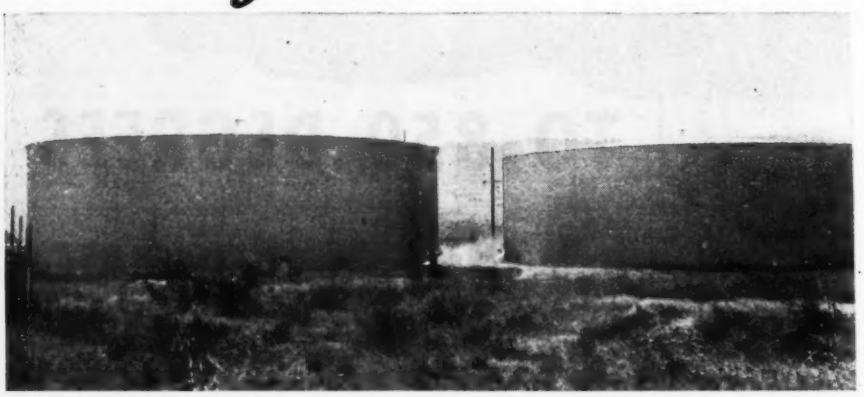
The Cooper-Bessemer engines are well known in the oil country and this new arrangement will simply add additional service to two already well established service institutions.

Win Recognition

The men and women of U. S. Steel's Oil Well Supply Company have for the third time won Army and Navy recognition.

Under Secretary of War Robert P. Patterson has notified the plant at Oil City, Pennsylvania, of the second renewal of its Army-Navy "E" flag.

Reilly PAINTS



will PROTECT YOUR TANKS—
and Exposed Metal Construction

★ Reilly paints fight corrosion on all metal construction that is exposed to the air, or for use under ground or under water.

REILLY COLD APPLICATION No. 40—For use on tanks, structural steel and other metal surfaces that are exposed to the atmosphere and to corrosive gases.

REILLY COLD APPLICATION No. 5—For use on tanks and other metal that is to serve under ground or under water. Also an excellent waterproofing agent for concrete.

REILLY COLD APPLICATION No. 50—Designed expecially to withstand erosion and abrasion, and the action of either fresh or salt water.

REILLY PIPE ENAMEL—For dependable protection to pipe lines. Used both as an inner lining and coating on steel water lines.

Reilly COAL TAR PRODUCTS

17 PLANTS To Serve the NATION

Booklet describing these Reilly Protective Coatings will be sent on request

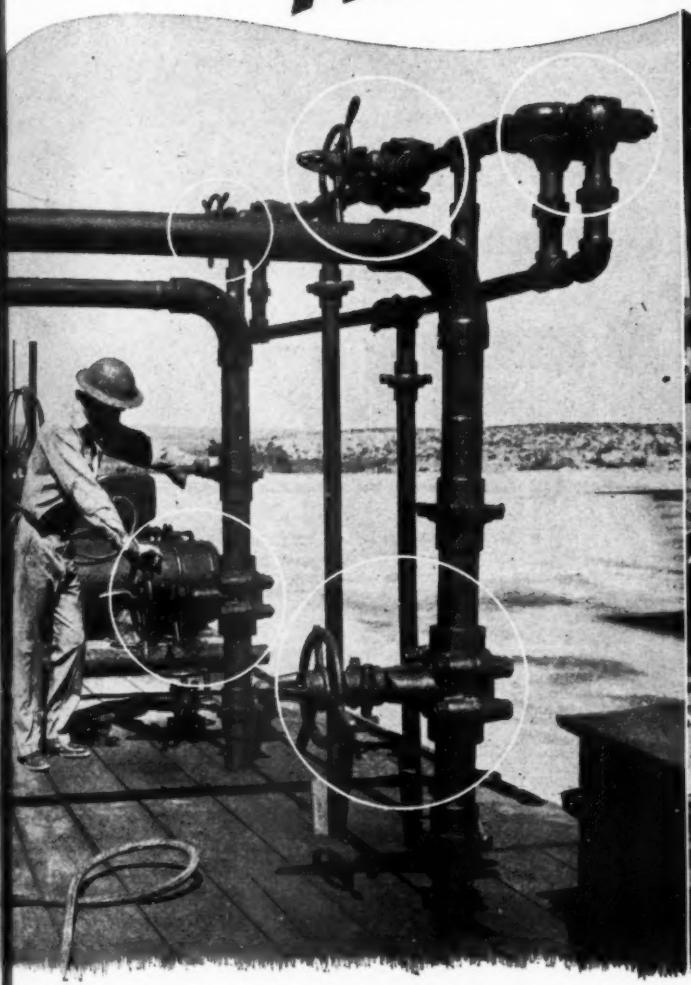
REILLY TAR & CHEMICAL CORPORATION
Merchants Bank Building, Indianapolis 4, Ind.
500 Fifth Avenue, New York 18, N. Y. • 2513 S. Damen Avenue, Chicago 8, Ill.

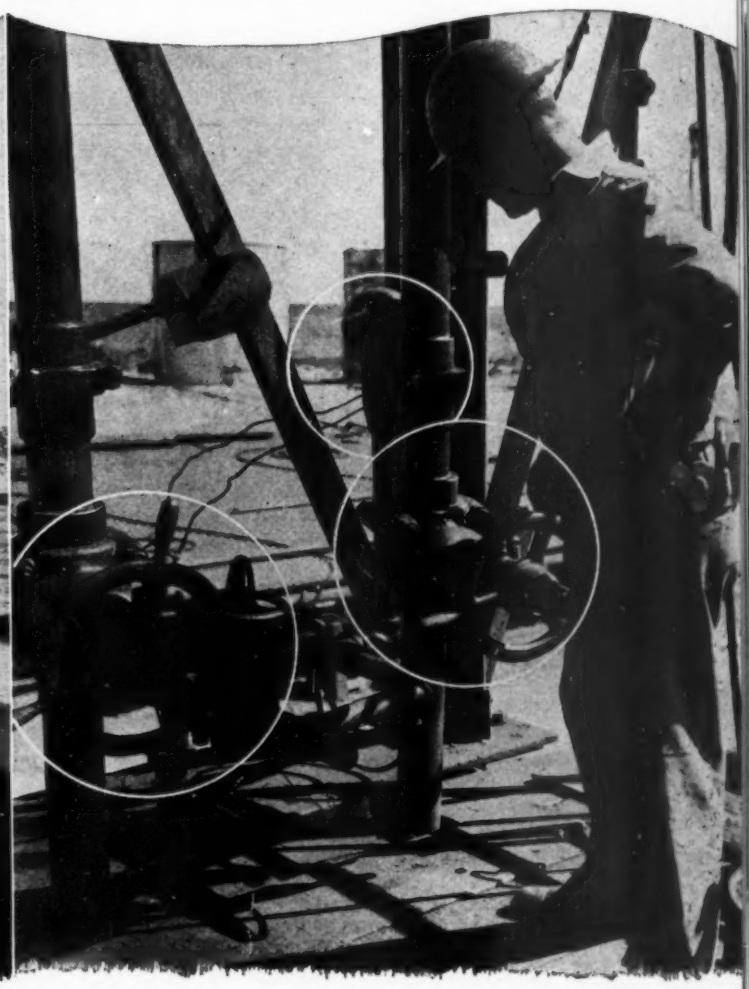
Reilly Protective Coatings

CAMERON EQUIPMENT HELPED CROWN

The New Champion!

Phillips Petroleum Company's Price No. 1, Pecos County, Texas





THESE CAMERON PRODUCTS HELPED DRILL THE WORLD'S DEEPEST HOLE

Shear Relief Valve

"Flex-Seal" Mud Line Valve

We of Cameron Iron Works join the industry in extending congratulations to Phillips Petroleum Company for its outstanding achievement.

We are naturally proud that a number of our products were selected for Price No. 1 — *Shear Relief Valves* to protect the pumps against excessive pressures; *Mud Line Pressure Gauge* to provide accurate, easily read mud line pressures; *Flex-Seal Mud Line Valves* to provide a dependable, pressure-tight shut-off when needed.

CAMERON IRON WORKS, INC.

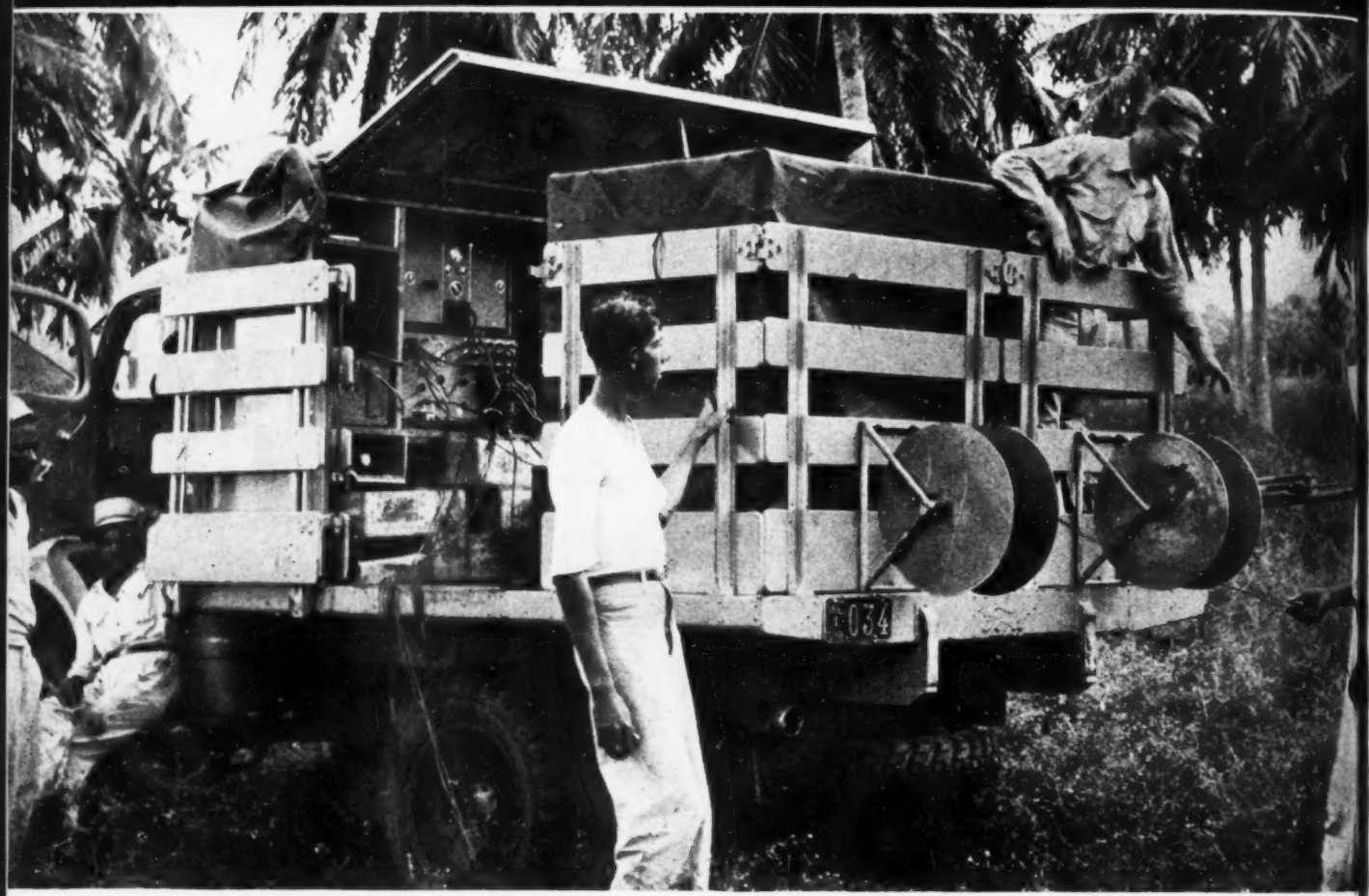
711 MILBY ST., HOUSTON, TEXAS

Export: 74 Trinity Place, New York, N. Y.

California: Howard Supply Co., Los Angeles

Rocky Mountain: Mountain Sales & Service, Casper, Wyo.

For Operations in SOUTH AMERICA
OIL COMPANIES PREFER
All-Wheel-Drive TRUCKS



● Making geophysical surveys of oil lands in South America is no Sunday picnic for the hard-bitten crews of jungle-fighting scientists, who lead the way into every new oil field.

Nor is it an easy job for transportation equipment. Only vehicles of unusual ability—ability to force their way through jungle muck and mud, to ford streams and climb steep grades—can be relied upon.

Just as the unit shown above is providing dependable transportation for a United Geophysical Company crew in Brazil, dozens of other Marmon-Herrington *All-Wheel-Drive* converted Fords are serving many similar companies in other regions of South America.

Practically all major oil companies and many independents, use Marmon-Herrington *All-Wheel-Drive*, at home and abroad, for the toughest hauling jobs in the oil fields. We hope it will not be long until more of them are available for these vital services.

★ *BACK THE ATTACK • BUY MORE BONDS!* ★

MARMON-HERRINGTON
All-Wheel-Drive TRUCKS

MARMON-HERRINGTON CO., Inc., INDIANAPOLIS 7, INDIANA

Cable Address: MARTON

Pemco Personnel Changes

Colonel W. F. Rockwell, president of Pittsburgh Equitable Meter Company, has announced several changes in the executive staff.

N. J. Kenny, formerly general manager of the National Meter Division in Brooklyn, has been transferred to the home offices in Pittsburgh where he will serve as assistant to Colonel Rockwell. Kenny has also been appointed chairman of the postwar products development committee.

A. R. WHITTAKER

N. J. KENNY

A. R. Whittaker, formerly factory manager of the National Meter Division, will assume the duties of general manager and has been placed in complete charge of all functions at the Brooklyn factory.

Guthrie Promoted

A. M. Guthrie has been advanced from eastern district manager to field sales manager of the Buckeye Traction Ditcher Company, according to an announcement by Paul B. Cochran, general manager.

"Al" is assuming the entire handling of distributor policies and appointments through the company's district managers. His headquarters will be at the plant, Findlay, Ohio, but, as postwar plans crystallize, he will travel extensively.

Globe Tool Official

Thos. H. Stancliff has been elected vice president of Globe Oil Tools Company, Los Nietos, California, and will be in charge of research and engineering work. Stancliff has been with the Reed Roller Bit Company for the last 15 years, having started with that company when roller bearings first were being developed for rock bits, and advancing to the position of assistant chief engineer. He has had active experience in virtually all major oil fields of this country, and his efforts have been responsible in a large measure for many new designs and developments in drilling tools during the last decade.

Wins $1000 Bond

T. W. Bell, The Texas Company, production engineer at Taft, California, was winner of the Fluid Packed Pump Company name contest. His name "Oilmaster" was awarded the first prize of a $1000 war bond. The purpose of the contest was to find a name that would identify all pumps manufactured by this company.

The five $50 war bonds were awarded as follows:

Harry Manes, Root-Rhodes Oil Company, Eastland, Texas.

Marvin A. Remke, the Carter Oil Company, St. Elmo, Illinois.

G. H. Hutchings, Annand-Hutchings Company, Cut Bank, Montana.

J. P. Crawford, Producers and Refiners, Inc., Oklahoma City, Oklahoma.

G. R. Lucie-Smith, Trinidad Leaseholds, Ltd., Trinidad, B.W.I.

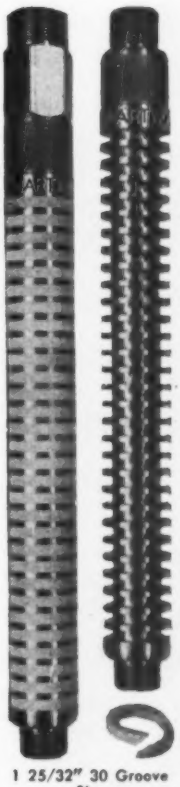
According to J. B. Reilly, president of Fluid Packed Pump Company, about 1000 participated in this unusual method of finding a new name for a line of products and the contest aroused widespread interest among oil men throughout the country.

LESS DOWN TIME, MORE OIL
At LOWER COST with
MARTIN PLUNGERS

Thousands of Installations Have Proved Their Efficiency . . .

In wartime it is important to recover every barrel of oil possible; to operate with the greatest efficiency, least amount of "down time" and repairs, to conserve labor and reduce costs, to prolong well life.

MARTIN PLUNGERS, with Exclusive One-Piece Body and Split Rubber-Fabric Rings, are your best wartime equipment. They are made to fit any size or make pump, and last two to five times longer.



1 25/32" 30 Groove Size

SOLD ONLY THROUGH SUPPLY STORES

See Page 1551 Composite Catalog

JOHN N. MARTIN
Manufacturer
11 W. Brady St. Tulsa, Okla.

Field Representatives

Tom Hulett, El Dorado, Ark.
C. J. Baeten, Wichita, Kans.
Lynn C. Holloway, Houston, Texas
Hugh Robinson, Blackwell, Okla.
F. M. Wilson, Wichita Falls, Texas
J. Walter Wade, Chicago, Ill.
E. C. Dilgarde, Casper, Wyoming

DAY NEVER ENDS IN THE OIL FIELDS

FWD Trucks work 'round the clock on the tough jobs . . . the long, difficult hauls

"When Day is Done" isn't just a song—in the oil fields. Because day is never done—the work-day, that is. With relentless determination that never sags, men work to draw out of the ground the lifeblood for our machines of victory. Strong, hardy men.

Strong, hardy trucks, too, are in demand, because much is expected of them. Men and gear, headed toward location, must cover terrain that can be negotiated only by trucks that can go through—regardless. FWD trucks outnumber all others for the tough hauls, the real difficult jobs, in the oil fields. FWD's take full loads to places you wouldn't think a truck could reach. Their dependable, unfailing hauling power is called on 24 hours a day—and FWD's go through.

FWD's true application of the four-wheel-drive principle, equalized power and load distribution, rugged construction, and great reserve power—these are the reasons for FWD's unchallenged leadership—in the oil fields and wherever the going is tough.

THE FOUR WHEEL DRIVE AUTO CO., Clintonville, Wisconsin

Canadian Factory: KITCHENER, Ontario

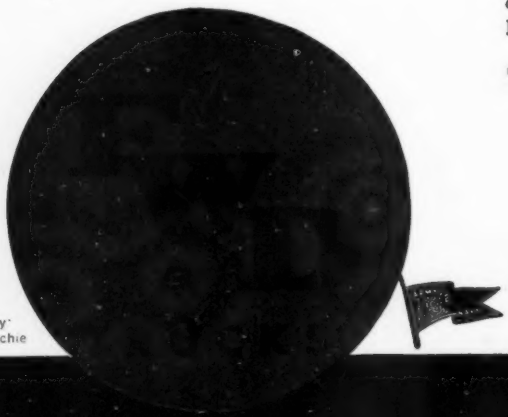


Photo by
nell Ritchie

IN EVERY FIELD WHERE TRUCK QUALITY IS PUT TO THE TEST—FWD's STAND UP

COMMERCIAL CONSTRUCTION UTILITIES OIL FIELDS MILITARY

Dramatizes Postwar Plan

A postwar program for full employment on a basis of free enterprise is the subject of a series of advertisements being released by Union Wire Rope Corporation, with headquarters at 2106 Manchester Avenue, Kansas City, Missouri. The ads are a condensation of the planned peacetime program of the American Road Builders' Association with illustrations that present dramatically the advantages of the plan.

Need of the effort that must be made to keep free enterprise free in America is stressed in the initial advertisement, published in this issue. It has a chart by which results of the American Road Builders highway building program can be visualized at once.

The Union Wire Rope Corporation "hopes that this series will serve to remind all industries of the responsibility in this direction that is definitely theirs and, perchance, point the way of doing something about it."

New Division Established

The industrial power division, with H. T. Reishus as general manager, on March 1, 1944, assumed direction of and responsiblity for International Harvester Company's entire industrial power business.

A division is a new unit in the Harvester company. It differs from a department in that a department deals with only one function, such as engineering or sales, whereas a division is a group of departments, each of which is engaged in its own functions but all of which are concerned with the same product or group of products.

H. T. REISHUS

NEAL HIGGINS

The industrial power division is a complete division with its own sales organization. Neal Higgins is manager of sales, and G. A. Gilbertson and W. M. Parrish are assistant sales managers.

Managers in addition to Higgins include: D. B. Baker, manager of engineering; H. B. Rose, manager of manufacturing; W. M. Holland, manager of supply and inventory, and M. L. Allen, divisional comptroller.

The sales department will function under Higgins, with the two assistant sales managers, and R. C. Flodin as assistant to the manager.

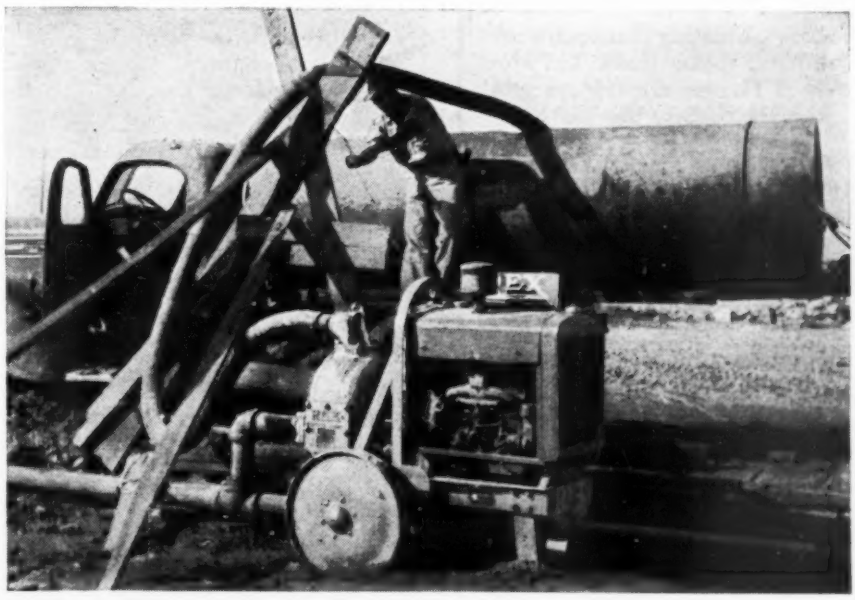
New Sales Manager

President J. C. Axelson of the Axelson Manufacturing Company, Los Angeles, announces the promotion of Alvin Zwerneman to the position of vice president and general sales manager.

This announcement closely follows Zwerneman's return from Washington where for 9 months he has been affiliated with the Petroleum Administration for War.

Before leaving for the national capital Zwerneman had a record of 20 years' service with Axelson.

FORMER ENGINEERING STUDENTS—Major oil company desires applications of persons who are interested in getting into the petroleum industry and who have been engineering or geological students in a reputable school or university. Experience helpful but not essential. Do not apply if employed in essential activity at highest skill. Address Box No. 9, care *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.



NEED A PUMP THAT WON'T QUIT?

. . . Rely on REX

NO matter how tough the going . . . no matter how long the working day, Rex Speed Prime Pumps don't quit on the job. They're built for rugged oil field service . . . built to keep pumping under conditions that would cause many pumps to call "quits."

Even when the suction line is leaking air, Rex Pumps keep right on delivering. For the patented "Air-Peeler," an exclusive advantage of Rex Pumps, literally peels air from the impeller and rushes it out the discharge.

Heavy oil and cutting-filled drilling mud doesn't clog Rex Pumps. Their "free-flow" design permits Rex Pumps to handle solids up to one-fourth the size of the intake . . . assures more efficient pumping performance.

For complete information about these and the many other advantages of Rex Speed Prime Pumps, send for your copy of Bulletin No. 434. Write Chain Belt Company, 1719 W. Bruce Street, Milwaukee 4, Wisconsin.

REX OIL FIELD PUMPS

CHAIN BELT COMPANY OF MILWAUKEE

ORBIT

MASTER VALVES WITH UNEQUAL FLANGES

The ORBIT GEAR OPERATED MASTER VALVE makes your Christmas Tree more compact by eliminating the use of an adapter flange—also eliminating chances for additional gasket leaks. The Unequal Flanges are cast integral with the body of the Valve.

Orbit Gear Operated Master Valve

This valve can be furnished through all fabricators of Christmas Trees or through any of your local supply stores at a price comparable to that of leading plug valves, YET, this valve requires no lubrication to effect a seal.

See Pages 2194 to 2211 in 1944 Composite Catalog

Specify

ORBIT VALVES

OIL WELL IMPROVEMENTS CO.

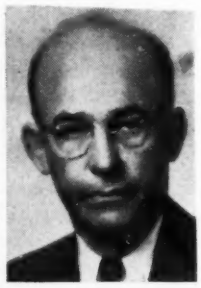
Since 1912

TULSA, OKLAHOMA

Running Tour

WITH MEN IN THE INDUSTRY

MEINHARD H. KOTZEBUE, president of the Gasoline Plant Construction Corporation, Houston, Texas, received the Hanlon Award at the annual convention of the Natural Gasoline Association of America at Dallas, Texas. He was the eighth recipient of the award, which is conferred each year for outstanding meritorious service to the natural gasoline industry. The citation stated that Kotzebue was primarily responsible for the introduction and development of high pressure absorption at natural gasoline and cycling plants and that his foresight and practical engineering judgment in the design and construction of such plants has saved production costs and conserved natural resources.



M. H. KOTZEBUE

W. W. SCULL has been appointed manager of the synthetic rubber plant being operated at Port Neches, Texas, by The B. F. Goodrich Company for the government, it is announced by William I. Burt, general manager of plants. Scull joined B. F. Goodrich in 1929 and had been operations manager of the Port Neches plant since last July.

A. J. JOHNSON, head of the engineering department, and HIRAM NORCROSS, manager of the New York office, have been elected vice presidents of the Shell Development Company, it was announced by A. E. LACOMBLE, president. Joining Shell in 1929, Johnson was first a member of the Norco refinery laboratory staff and later became assistant department head. In 1936 he was transferred to St. Louis and subsequently to Houston, where he was assistant superintendent of the refinery. In 1940 he went to San Francisco as head of the engineering department. Norcross joined Shell Oil Company in 1933. In 1941 he was transferred to the headquarters of Shell Development Company in San Francisco and a year later became manager of the New York office.

H. H. CHAMPLIN, 76, head of the Champlin Refining Company, Enid, Oklahoma, died April 30 after more than a year of poor health. Champlin was a pioneer in the Oklahoma oil industry.

ROBERT S. PEARE, manager of publicity and broadcasting for the General Electric Company since 1940, and chairman of the company's general advertising committee, has been elected a vice president by the board of directors. Peare will direct the company's advertising, broadcasting, and general publicity activities as a member of the president's staff.

EDWARD F. DEACON, president of Climax Engineering Company, Clinton, Iowa, and the McAlear Manufacturing Company, of Chicago, Illinois, announces the appointment of ALLEN S. GEORGE as special representative for Climax and McAlear products and engineering specialties in the Mid-Continent and Southwest areas. For the present, George will operate from his headquarters at 3416 Cockrell Street, Fort Worth, Texas.

A. S. GEORGE

E. J. DALY, Wickwire Spencer Steel Company, Houston, Texas, has been informed that his son, Lieut. Jack J. Daly, was decorated with the Air Medal in recognition of courageous service in the Southwest Pacific area. Jack flies a P-38 Lightning in a fighter squadron and is still in that area, according to his letters. Most of his exciting experiences must await the war's end for telling.

Bethlehem Supply Company announces the appointment of HARVEY E. DAVIDSON as chief engineer in the manufacturing division of its Tulsa plant. He will be in charge of design of products manufactured by the company at Tulsa.

Davidson has had several years' experience in this kind of work, having been associated with Cardwell Manufacturing Company of Wichita, Kansas, and more recently with Unit Rig and Equipment Company of Tulsa.

H. E. DAVIDSON

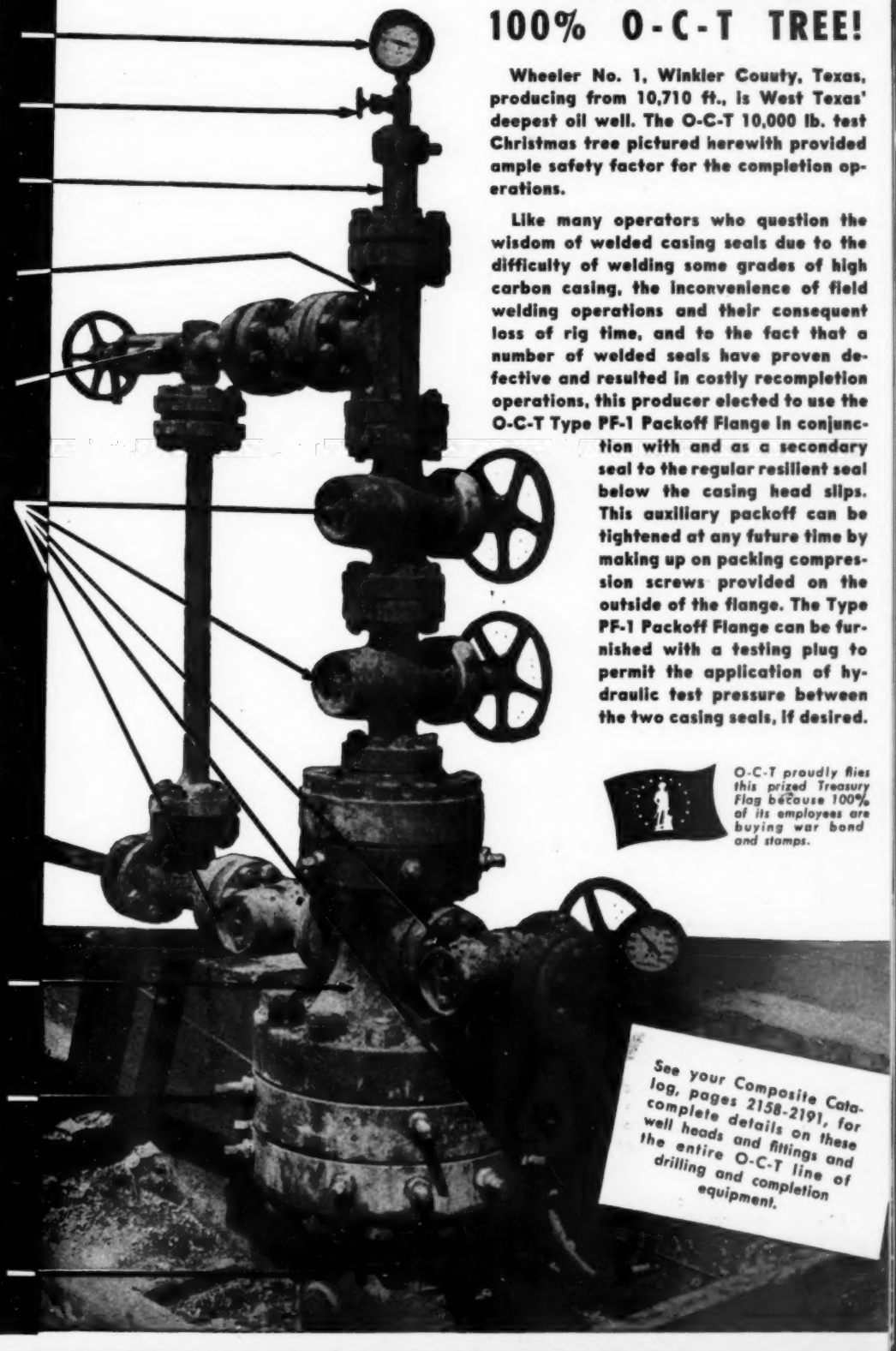
WEST TEXAS' DEEPEST *Oil Well*

IS FLOWING THRU A 100% O-C-T TREE!

Wheeler No. 1, Winkler County, Texas, producing from 10,710 ft., is West Texas' deepest oil well. The O-C-T 10,000 lb. test Christmas tree pictured herewith provided ample safety factor for the completion operations.

Like many operators who question the wisdom of welded casing seals due to the difficulty of welding some grades of high carbon casing, the inconvenience of field welding operations and their consequent loss of rig time, and to the fact that a number of welded seals have proven defective and resulted in costly recompletion operations, this producer elected to use the O-C-T Type PF-1 Packoff Flange in conjunction with and as a secondary seal to the regular resilient seal below the casing head slips. This auxiliary packoff can be tightened at any future time by making up on packing compression screws provided on the outside of the flange. The Type PF-1 Packoff Flange can be furnished with a testing plug to permit the application of hydraulic test pressure between the two casing seals, if desired.

O-C-T proudly flies this prized Treasury Flag because 100% of its employees are buying war bond and stamps.



See your Composite Catalog, pages 2158-2191, for complete details on these well heads and fittings and the entire O-C-T line of drilling and completion equipment.

QUALITY O-C-T PRODUCTS

"Selling Through Leading Supply Stores"

OIL CENTER TOOL COMPANY

HOUSTON, TEXAS, U·S·A

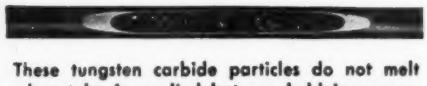
Export Representative: Val R. Wittich, 30 Rockefeller Plaza, New York, N. Y.

Tube Borium Keeps 'em digging

DULL IN 3 DAYS
STILL SHARP AFTER 30 DAYS
STOODY TUBE BORIUM* KEEPS DITCHER TEETH SHARP ...ELIMINATES FREQUENT SHUT-DOWNS FOR TOOTH CHANGES...CUTS REPLACE-MENT COSTS UP TO 75%

The two ditcher teeth pictured above were used on the same machine and operated under identical conditions.
The unprotected tooth at the top had to be sharpened every three days and was too short for further service after six sharpenings.
But the Borium-protected tooth at the bottom operated for 40 days and wore only ½". It was simply resharpened in the forge, retipped with Tube Borium, and put back on the ditcher for another 40 days' service.
Before the tooth was finally worn out, it had operated a total of 120 days!
Tube Borium makes such savings possible because the deposits represent the ultimate in wear resistance and the ability to cut hard earth formations.

*Stoody Tube Borium is supplied in rods of ⅛", 5/32", ¼" and ⅜" diameters and is available for either oxyacetylene or D.C. electric application. Prices and specifications are yours for the asking.



These tungsten carbide particles do not melt when tube is applied but are held in suspension in a mild steel matrix forming a deposit resembling coarse sandpaper.

Send for free booklet on TUBE BORIUM, showing sizes and styles of rods and recommended methods of application.

STOODY COMPANY
1142 West Slauson Ave., Whittier, Calif.

STOODY HARD-FACING ALLOYS
Stop wear . . . Eliminate Repair

LAUGH WITH BARNEY

Three salesmen were eating dinner in a Washington hotel. The bill was $30 and all reached for the check. The first fellow said his firm was in the 50 per cent bracket, doing war work, and that the bill actually would cost him only $15. The second man said, "Let me pay it. We're in the 80 per cent bracket and it will cost me only $6." The third one said, "I'll pay the check. My firm is working on a cost plus basis and we'll make $3 on the meal."

* * *

An oil field worker went into a drug store and after looking carefully around, said to the clerk:

"Say, I want you to fix me up a great big dose of caster oil so it won't taste."

"Sure," the clerk replied, "but it'll take a little time. Would you mind having a cup of coffee until I get it ready?"

About ten minutes later the worker called the clerk.

"Say, what about the shot of castor oil I asked for?"

"Oh that," the clerk grinned. "You drank it in the coffee."

"Coffee, hell!" the worker shouted, streaking for the door, "I wanted that for my foreman."

* * *

Insurance man putting questions to a cowboy: "Ever had any accidents?"

"No," was the reply.

"Never had any accident in your life?"

"Nope, a rattler bit me once, though."

"Well, don't you call that an accident?"

"Hell, no. He bit me on purpose."

* * *

"Where didja get that black eye?"

"For kissing the bride after the ceremony."

"Isn't that the usual custom?"

"But this was three years after the ceremony."

* * *

"Vacation plans don't bother me," said William Henry Penny. "My wife decides where I shall go, and my employer when."

* * *

A Swede walked into the ticket office and asked for a ticket to Chicago.

"Do you want to go by Buffalo?"

"My gudeness, no, ef Ay can't go by train geeve me reindeer."

* * *

Wife: Good heavens, George, this isn't our baby! This is the wrong carriage!

George: Shut up! It's got rubber tires.

A traveling salesman stopped to buy some corn from a mountaineer. "It's too bad about the war," he remarked after the corn had been paid for.

"War?" asked the old man, "Is two countries afightin' a war?"

Surprised, the salesman said "Yes, many countries and it's a big one this time."

The old man thought this over for a minute and said, "Well, they've got a good day for it."

* * *

A woman went into a bank to buy a War Bond.

"What denomination?" asked the clerk.

"Presbyterian," she answered.

* * *

Ex-Service Man: So you were in the Army, Ikey.

Ikey: Oh yes, I vas in the Army.

Did you get a commission?

No, only my wages!

* * *

There was once a man in our town who was a heavy drinker. "You ought to quit it, John," a doctor friend advised. "Quit it, and I'm sure you'll live longer."

He promised to do so, and some time later his friend asked him how he was making out. "I am sure you were right about living longer," he said. "I tried it a full day, and it was the longest day I ever lived."

* * *

A man who had been called for jury service asked to be excused.

"On what grounds?" asked the judge.

"We're so busy at the office, sir, and I ought to be there."

"So you are one of those men who think they are indispensable; you think that the firm cannot do without you. Is that it?"

"No, sir; far from that. I know very well they can, but I don't want them to find out."

"Excused," said the judge.

* * *

A newly rich Irishman in street dress walked into an exclusive club the other night and one of the attendants called his attention to a sign, reading "Patrons must wear full evening dress." Pat squinted at it for a few minutes and then inquired disdainfully: "Who's smoking?"

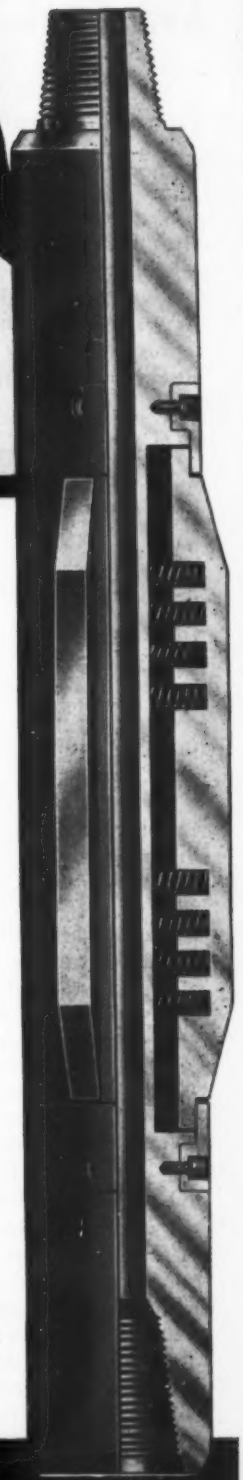
* * *

Ethel: My father always proposed a toast before he disciplined me.

May: That's funny. What was it?

Ethel: Bottoms up.

"We figure that our Casing Scraper rental has been all paid for by savings on swabs and packer rubbers."



POSITIVE RESULTS, PROVEN ECONOMY

Are Swinging Operators Everywhere to the

BAKER ROTARY CASING SCRAPER

- **Make Sure Your Casing Is Clean and Smooth**
- **Remove Sharp Burrs from Gun-Shot Holes**
- **Avoid Damage To Packers and Swabs**
- **Easily Used by YOUR Crews**
- **Make Future Work Safe and Easy**
- **Low-Cost Rental**

Reach for your 1944 Composite or Baker Catalog, turn to

Page 357

FOR RENT in all Domestic Oil Fields

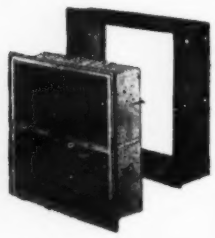
BAKER OIL TOOLS, INC.

MACHINERY and EQUIPMENT

Viscous Panel Filter

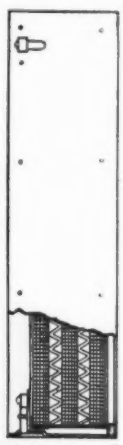
DOLLINGER Corporation (formerly Staynew Filter Corporation) announces a new viscous panel filter. Designated as Model DPV, the new filter is offered primarily for application in ventilation and air conditioning systems where filter resistance up to approximately 0.60 in. of water is permissible.

The Model DPV filter is a scientifically designed cell, the filtering medium consisting of a series of crimped layers of galvanized screen cloth and woven copper mesh. This medium, when coated with Pingene PD-10 filter oil, forms an unusually efficient filter, it is stated. The medium is so arranged within the metal cell that it provides extremely large dirt-holding capacity, thus requiring a minimum of servicing.



Model DPV cell and frame assembly

The cells are unusually heavy, being made up of 16-gauge steel finished attractively with a corrosion-resisting paint, and are fitted with handles and cam-type locking latches that hold the cell tightly in place in its box-type supporting frame, thus positively sealing the unit against air leakage. The box-type supporting frames are so designed and drilled that they can be riveted together to form a flat bank, or, by the addition of angles, a series of "V's," so that a maximum of filter capacity can be installed for any given space.



Sectional view of Model DPV showing crimped layers of filtering media

Colored Filters

A new development in respiratory safety by Mine Safety Appliances Company is its M.S.A. colored filters for M.S.A. Comfo and Dustfoe respirators. Designed for use with these modern, dust respirators, each of the three types of filters has its own distinctive color. The color shows through the transparent Dustfoe and open Comfo filter containers and permits inspection at a glance of the filter type employed, without removal from the respirator.

Thus, states the manufacturer, the filter type is constantly in view for worker, foreman, and safety inspector, helping to assure correct filter use for each type of job. Workers are able to associate quickly color of filter with its dust and fume protective classification.

Further details on M. S. A. colored filters are available from Mine Safety Appliances Company, Braddock, Thomas and Meade Streets, Pittsburgh 8, Pennsylvania.

Rex Uni-Flow

CHAIN Belt Company, Milwaukee, Wisconsin, announces the manufacture of a new conveyor-elevator system to be known as the Rex Uni-Flo. This type of conveyor is a new and unique method for the mass handling of free-flowing bulk materials.

The new Rex Uni-Flo is a conveying unit of the continuous-stream type. It is composed of a chain belt equipped closely-spaced scraper-carrier flight, which operates in an enclosed casing. With the entire cross-section of the casing and all the space between the flights solidly filled with the material being handled, a continuous flow of material results.

Rex Uni-Flo has many distinguishing features. It has a positive and unique discharge mechanism that definitely removes all material in the conveyor system at the point of discharge, it is stated. It is completely self-feeding and no auxiliary feeding devices are required. Rex Uni-Flo is self-cleaning and has a minimum of churning and degradation of materials either while in operation or after the feeding has stopped. it operates at relatively slow speeds, which means longer life and freedom from maintenance worries.

Rex Uni-Flo is flexible in application with a wide choice of basic units and few limitations as to layout. It can convey material horizontally, vertically, or at any angle. It offers a direct line of transportation by the shortest possible route to conserve valuable productive space. Because it is essentially a closed-circuit method of handling, it is clean and dust-free.

Chain Belt Company also manufactures many other types of bulk material conveyors including belt conveyors, apron feeders, bucket elevators, scraper conveyors, and a complete line of power transmission chain belts and machinery.

Bulldozer and Trailbuilder

A NEW cable-controlled bulldozer and trailbuilder, known as the "Centro-Lif," has been announced by the Buckeye Traction Ditcher Company, Findlay, Ohio. The new Centro-Lif is currently offered in two models, one weighing 5855 lb., without the power control unit, for Allis-Chalmers HD-14 tractors, and the other, weighing 5140 lb., without the power control unit, for Allis-Chalmers HD-10-W tractors. Both models are controlled by Buckeye single or double drum power control units. The new design is engine mounted and cable is carried overhead from winch to moldboard.

The principal new feature is the center lift construction of the moldboard, which provides many advantages: Light weight for its size, simple construction, and straight lift of the blade. The horn is designed so that the moldboard is close to the tractor radiator. The push arms are so constructed that the moldboard pivots about a single king pin and can be angled to the right or left by removing two landside pins, swinging the moldboard to the desired side, and replacing the landside pins. The moldboard can also be easily tilted by means of a double trunnion mounting of the push arms. By attaching one push arm to the top trunnion on one side while the other arm is mounted on the lower trunnion on the opposite side, a vertical adjustment of 12 in. at end of moldboard is provided.

Maximum height of lift of leading corner of blade is 53 in., whereas digging depth of blade below grade is unlimited. Trailbuilder moldboard is 12 ft. 9⅝ in. long and 37 9/16 in. high and is fitted with reversible cutting edge and replaceable corner bits.

ASSEMBLED and TESTED by RECTOR on RECTORHEADS

FURNISHED IN THE FOLLOWING COMBINATIONS:

6,000-lb. test Casing Head with 10,000-lb. test Tubing Head.
4,000-lb. test Casing Head with 6,000-lb. test Tubing Head.
6,000-lb. test Casing Head with 6,000-lb. test Tubing Head.
4,000-lb. test Casing Head with 4,000-lb. test Tubing Head.

RECTORTREES assembled and tested in both Wichita Falls and Houston Plants.

This RECTORTREE permits you to drill your well with a 6,000-pound test Rector Casing Head before you know whether an equal or a higher test tubing head is required for completion and producing. Use of the restricted seal ring gives all the safety features of a higher pressure casing head.

NO FABRIC PACKING IS USED IN THE RECTOR CASING HEAD FOR A PERMANENT SEAL... NO INTERMEDIATE FLANGE BETWEEN CASING AND TUBING HEAD... OR OTHER ACCESSORIES ... NECESSARY FOR SURE, SAFE CONTROL OF YOUR WELL... A.P.I. BOLTS, IN SIZE AS WELL AS LENGTH, USED IN THIS CONSTRUCTION.

Refer to your 1944 Composite Catalog... or write for a copy of the new 1944 Rector Catalog, just printed.

RECTOR WELL EQUIPMENT CO., INC.

FT. WORTH, TEXAS

Export LUCEY EXPORT CORP, Woolworth Bldg., N Y C

Representatives in Active Fields

SUCCESSOR TO THE BRADENHEAD

New GE Motor

AN electric motor operating at the record-breaking speed of 120,000 r.p.m., or more than 7,000,000 r.p.h., has been built and tested by General Electric Company. The motor was developed for application to internal grinding machines used in finish grinding small holes, many less than ¼ in. in diameter, in vital war parts. Although the motor will not be available for general use until after the war, another possibility for its use is in driving small drill chucks for drilling tiny holes in soft metals, using drills 1/32 in. in diameter and less.

According to F. W. Baumann and D. H. Ware, G-E motor engineers, the surface speed required to produce a high-grade finish economically by grinding should be about the same whether grinding a large or small hole. A medium size wheel rotating at a moderate speed gives the requisite surface speed but for small holes only a tiny grinding wheel can be used, hence the high rotating speed is essential.

With normal voltage applied at 2000 cycles, the new motor reaches full speed in less than a second. It is rated 3 hp. and weighs but 7 lb. as contrasted with the standard 3-hp., 1800-r.p.m. motor that weighs 105 lb. The motor is so small that it fits into the palm of a person's hand, while its rotor is scarcely larger than a man's thumb.

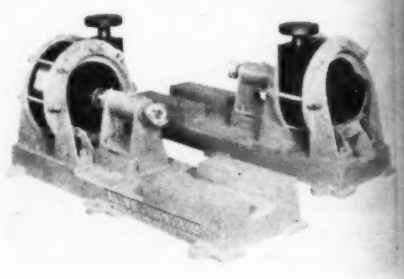
Tests the motor has passed successfully at 120,000 r.p.m. include 8-hr. continuous runs at rated horsepower as well as grinding tests with a tiny grinding wheel mounted directly on the motor shaft.

Problems entering into the design of the motor were largely of a mechanical nature. As the utmost in smooth operation is an essential to precision grinding, ultra-precision bearings with practically perfect dynamic balance were required. A special oil-mist lubricated type of bearing is used.

Corrosion Resistant Pump

A CORROSION resistant centrifugal pump designed by National Carbon Company, Inc., for the chemical process industries is now out of the experimental stage and has been standardized in three sizes.

Constructed of chemically inert "Karbate" material, which is a carbon stock made impervious to seepage of



liquids under high pressure, the pumps have shown excellent performance and servicability under plant operating conditions in a variety of chemical applications.

Their resistance to almost all corrosive fluids, including acid mixtures such has HCL and H_2SO_4, gives the Karbate pumps a longer life span and at the same time avoids metallic contamination of liquids being handled, the makers state. Karbate pumps may be used without danger where sudden variations of fluid temperature induce thermal shock, it is stated.

The largest of the three pumps operates against a 100-ft. head. They are so engineered that from inlet to outlet the liquids are in contact with the Karbate material. The Karbate sleeve covers the steel shaft, and is cemented to the impeller disk rather than to the shaft itself. The shaft end is covered with the Karbate cap. The pumps are sealed with a rotary faced seal, thereby eliminating the maintenance problems inherent in stuffingboxes.

For almost every *heavy duty* application where the load is radial, there is an adaptable, durable, dependable AMERICAN RADIAL ROLLER BEARING capable of withstanding the tremendous stresses and strains demanded by the ponderous equipment and stepped-up tempo of today's manufacturing. And because they are *specially* designed for 'tough going', AMERICANS render smooth, continuous, trouble-free service under the most adverse operating conditions, resulting in lower maintenance costs and increased performance-life of heavy machinery and equipment.

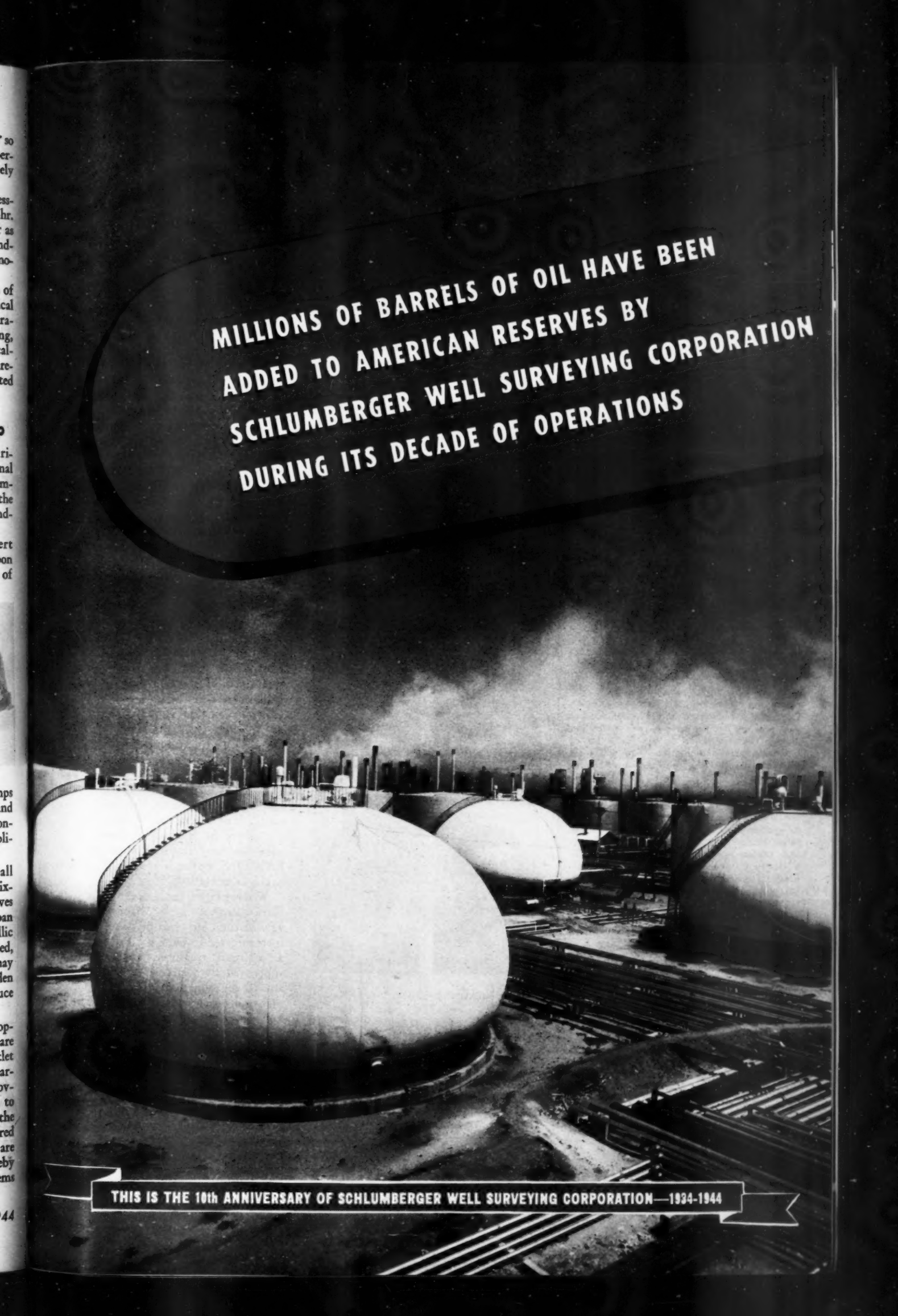
AMERICAN RADIAL ROLLER BEARINGS are made in 5 styles 4 S.A.E. series and 85 sizes. Special designs to order are also available. Consult our engineering department on all your roller bearing problems. Write today!

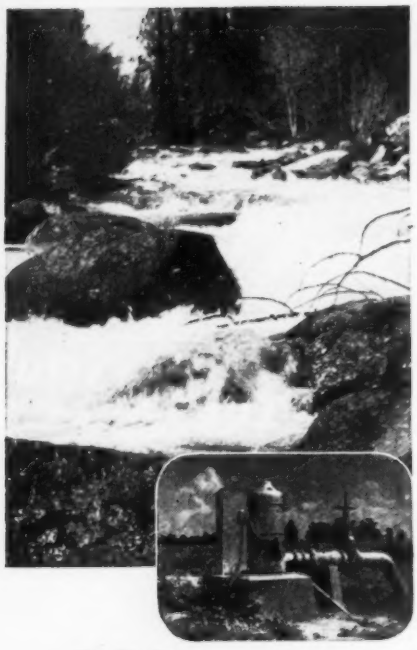
AMERICAN ROLLER BEARING CO., Pittsburgh, Pa.

***Pacific Coast Office:* 1718 S. Flower St., Los Angeles, Calif.**

AMERICAN ROLLER BEARINGS HEAVY DUTY

AMERICAN
Heavy-Duty ROLLER BEARINGS


MILLIONS OF BARRELS OF OIL HAVE BEEN
ADDED TO AMERICAN RESERVES BY
SCHLUMBERGER WELL SURVEYING CORPORATION
DURING ITS DECADE OF OPERATIONS
THIS IS THE 10th ANNIVERSARY OF SCHLUMBERGER WELL SURVEYING CORPORATION—1934-1944



WATER
WILL BE AN
URGENT POSTWAR NEED

Maybe it is entirely too early to order your postwar Water System. Maybe you can't even determine the amount of water you may need. But you do know that you are going to be pretty "hard boiled" about such things as long-life quality—top flight efficiency—and extra low operation cost.

Summing it up, you are going to demand the very features that have made Layne Water Systems world famous. But you are not going to buy on reputation alone. You are going to ask for a lot of bed-rock facts and figures. You will want to know exactly what you are getting for your dollars.

Fortunately, you are going to be the very kind of prospect that Layne likes to meet—the kind of buyer that will understand and fully appreciate the incomparably fine features found only in Layne Turbine Pumps and Water Systems. You are going to be a dandy postwar customer, and like hundreds of other "look before you leap" buyers, you are going to be a 100 percent satisfied Layne customer.

For literature and further facts, address Layne & Bowler, Inc., General Offices, Memphis (8), Tenn.

AFFILIATED COMPANIES: Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City, Mo. ★ Layne-Western Co. of Minnesota, Minneapolis, Minn. ★ International Water Supply Ltd., London, Ontario, Canada

LAYNE

WELL WATER SYSTEMS
DEEP WELL PUMPS

BUILDERS OF WELL WATER SYSTEMS FOR INDUSTRIES AND MUNICIPALITIES

"Oilwell" Changes

Fred F. Murray, president of Oil Well Supply Company, U. S. Steel subsidiary, has announced appointments and reassignments of sales department personnel throughout his organization. Because of the numerous field establishments of Oil Well Supply Company, the reassignments are nationwide in scope.

F. F. MURRAY

Lloyd E. Tracy has been appointed general manager of sales, with headquarters at Dallas, Texas. He will be assisted by F. D. Smith and A. C. Michaelis.

L. E. TRACY

G. A. HAYS

George A. Hays, vice president with headquarters at Dallas, will devote his full time to major sales problems in all domestic areas.

John M. Post will continue as manager of the tubular division of the general sales department, with headquarters in Pittsburgh, Pennsylvania. He will be supported by F. W. Little, assistant manager of the tubular division.

V. J. Waters, as a member of the general sales department, will continue as manager of the used equipment department and manager of the merchandise claims department, with headquarters at Dallas. M. D. Routzon has been appointed assistant manager.

Kenton Chickering will continue to head the advertising and catalog section.

M. E. Nicklin will continue as manager of the export division and will be supported by M. E. Keenan, manager of export sales. The export division office is in New York City.

R. R. McAfee, Columbus, Ohio, succeeds F. D. Smith as manager of the eastern division, and will be supported by C. H. Maynard, assistant manager, eastern division, and L. M. Woltz, tubular sales representative, eastern division, both located at Columbus, Ohio.

K. B. Winstead succeeds Tracy as manager of "Oilwell's" midwest division and will make his headquarters at Dallas. He will be supported by R. H. Christy, assistant to the division manager, Dallas; William Heldmar, assistant division manager at Tulsa, Oklahoma; Carl C. Egner, assistant division manager at Houston, and later by Paul H. Shepherd, assistant division manager at Fort Worth, Texas. Shepherd is now on leave of absence in Washington, D. C., where he is chief of facilities review section, transportation division, PAW. J. S. Fuller is appointed division engineer at Dallas.

J. M. POST

V. J. WATERS

Warner F. Parker, Los Angeles, California, succeeds L. L. Mitchell as manager of the California division. Mitchell is transferred to Oil City, Pennsylvania, as assistant treasurer. Parker will be supported by Clarence J. Hill, assistant to division manager; R. F. Cann, manager of tubular sales; R. T. Watkins, manager of machinery sales, and Albert Lasken, Jr., manager of stores and general sales, California division.

M. E. NICKLIN

R. R. McAFEE

District manager appointments include: Harold Wright, succeeding L. M. Woltz as manager of the Ohio district, with headquarters at Columbus; C. L. Benezette, Mt. Pleasant, Michigan, succeeding C. H. Maynard as manager of the Michigan district, and C. A. Bell, Houston, Texas, manager for the Gulf Coast district, succeeds R. H. Christy.

K. B. WINSTEAD

W. F. PARKER

ON THE
CONTROL OF FLOWING WELLS

. 11 1944 DALLAS, TEXAS

OVER 800 INSTALLATIONS OF THE OTIS TYPE-G SIDE DOOR CHOKE

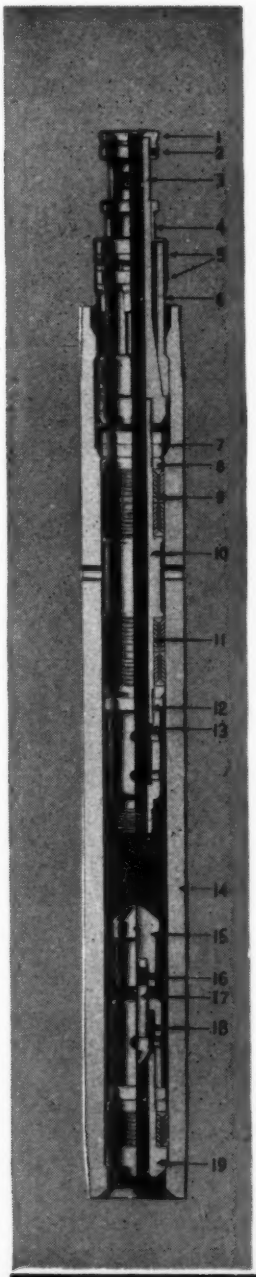
DESCRIPTION and OPERATION

The Type G Choke Assembly is made up of three principal parts: the Landing Nipple, the Side Door Choke assembly, and the Check Valve assembly. The Landing Nipple is made up in the tubing string at the time the tubing is run; whereas the Side Door Choke and Check Valve assemblies are run and pulled under pressure on an ordinary steel measuring line any time after the tubing is installed.

The purpose of the Landing Nipple is to provide a fluid course between the tubing and casing—and to serve as a definite lock and seat for the Side Door Choke and Check Valve.

The Side Door Choke assembly consists of a locking device and a pack-off section. The locking device holds the Side Door Choke assembly in place under all conditions. The pack-off section directs the flow of the upper and lower zones by means of two sets of V-type packings on a mandrel, so arranged that they prevent flow around the outside of the pack-off section regardless of which zone offers the greater pressure. If desired, a flow bean may be made up in the lower end of the packing mandrel to control flow from the lower zone.

The Check Valve assembly prevents downward flow through the Landing Nipple into the lower zone. The tool is simply a ground seat drop check valve mounted on a packing mandrel that completely plugs the bore of the Landing Nipple when a greater pressure exists above the Check Valve.



1. *Retaining Nut*
2. *Set Screw*
3. *Mandrel*
4. *Slip Carrier*
5. *Bands*
6. *Locking Dogs*
7. *Upper Split Packing Nut*
8. *Packing Ring*
9. *Upper Chevron Packing*
10. *Side Bean Packing Mandrel*
11. *Lower Chevron Packing*
12. *Lower Packing Nut*
13. *Bean Cage*
14. *Landing Nipple*
15. *Nut*
16. *Rivet*
17. *Drop*
18. *Valve Cage*
19. *Cup Mandrel*

Aid in Completing and Producing Multi-Zone Flowing Wells

The Type G Otis Removable Bottom Hole Choke, by its complete control of the oil and gas flow, has been generally accepted by the oil industry as standard equipment for use in completing and producing multi-zone flowing wells.

The most common uses of the Side Door Choke for Multiple-Zone Completions are:

1. To provide a means to positively open and close flowing or circulating ports in the tubing string after the packer has been set and surface connections permanently installed.
2. To utilize gas from an overlying gas zone to assist the flow of oil from a lower zone.
3. To provide a means to take pressures of each zone of a two-zone well independently of the other.
4. To kick-off the annulus should it become loaded up.
5. To acidize either zone independently of the other zone.
6. To recondition mud back of a packer without exposing the pay zone to the mud column.

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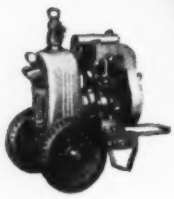

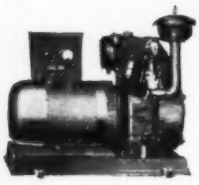

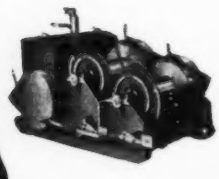

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TRADE LITERATURE
What to Write For

SPERRY-SUN WELL SURVEYING COMPANY will send a reprint of an article recently published on how the gyroscopic clinograph operates if a request is addressed to Philadelphia, Pennsylvania, Houston, Texas, or Long Beach, California.

LITERATURE with full information on its various tools has been published by Grant Oil Tool Company, 2042 East Vernon Avenue, Los Angeles 11, California, and will be sent free. Specify the tools in which you are interested.

THE CURRENT ISSUE of the Honan-Crane publication *"On Land and On Sea"* reviews the highlights of current oil shortages and the part that oil purification can play in relieving the shortage. Other topics concerning how to extend safely the useful life of oil, savings represented by effective purification, range of application of oil purification equipment, etc. A letter to Honan-Crane Corporation, 202 Wabash Avenue, Lebanon, Indiana, will bring a copy.

"PETROLEUM REFINING PROCESSES" is the title of an informative 54-page book just published by The Lummus Company, 420 Lexington Avenue, New York, 17, N. Y. The book presents material concerning the fundamentals of thermofor catalytic cracking, the Houdry process, 100-octane gasoline and other timely subjects. An interesting feature of the work is the inclusion of 17 schematic flow sheets concerning T.C.C., Houdry catalytic process, etc.

AN ILLUSTRATED and highly statistical 70-page book on synthetic rubber has just been made available to users by the Acadia Synthetic Products division of Western Felt Works, Chicago. Laboratory evaluations of compounds made from the various synthetic polymer when they have been exposed to various oils, fuels, and solvents are presented.

Made Assistant Manager

W. R. DIXON of The Dow Chemical Company has been named assistant manager of the company's plastic engineering division at Midland, Michigan. Dixon joined the organization in 1936 and was assigned to cellulose products division. In 1939 he was transferred to the New York office to handle cellulose products there. He was recalled to the home plant in 1941.

Huizinga Promoted

A. T. HUIZINGA

Election of Albert T. Huizinga as vice president and treasurer is announced by the National Supply Company, Pittsburgh. Huizinga joined the company as treasurer, July 19, 1943, coming from Montgomery Ward & Company, Chicago.

Haggerson Heads U.C.C.

At a meeting of the board of directors April 25, Fred H. Haggerson, vice president and director, was elected president of Union Carbide and Carbon Corporation, succeeding Benjamin O'Shea who has been president since 1941 and now becomes chairman of the board. Haggerson has been associated with Union Carbide and Carbon Corporation for 25 years.

F. H. HAGGERSON

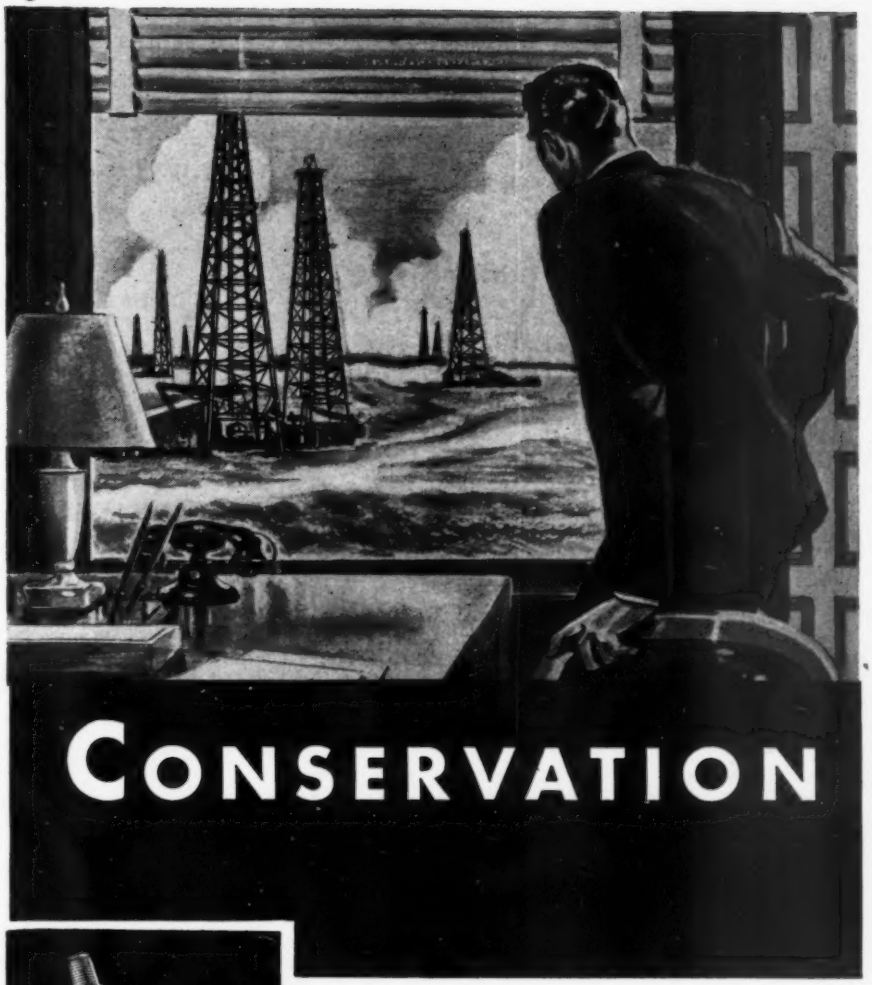
Names New Distributor

The A. O. Smith Corporation, Milwaukee, Wisconsin, announces the appointment of Pacific Metals Company, Ltd., as distributor in California, Nevada, and Arizona for SMITHway certified electrodes, a-c. welders, and other welding equipment. Substantial stocks of these products will be carried in Pacific Metals' warehouses at 3100 Nineteenth Street, San Francisco, and at 1400 South Alameda Street, Los Angeles.

Opens New York Office

The Votator Division of the Girdler Corporation announces the May 1 opening of a New York office at 150 Broadway with S. N. Welch as the eastern representative.

MAJOR OIL COMPANY has openings available for graduate petroleum engineers having at least three years acceptable experience general oil field development. Salary open. All hiring will be done in accordance with WMC Stabilization Plans. Reply to Box No. 7, care *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.



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American Steel Readjustments

The American Steel and Wire Company, U. S. Steel subsidiary, announces readjustments designed to increase service to the oil field country.

On January 1, 1944, the Dallas office of American Steel and Wire Company took over direction of all sales and service in connection with drilling lines, oil field wire rope, bailing lines, and other products produced specifically for the oil industry.

E. T. EGGERS

Distribution will continue to be effected through jobbers in various parts of the area and stocks of oil field wire rope for serving the industry will be maintained at Tulsa, Oklahoma, Denver, Colorado, and Houston, Texas.

The Dallas set-up is coordinated with the southwestern distribution outlet for American Steel and Wire Company at Houston.

Edwin T. Eggers, Dallas, is midwest manager in the oil field wire rope division of the company.

The Denver office is an entity within itself, covering the Rocky Mountain area. It is managed by Thurman Haskell. MacKeon Stewart is assistant manager.

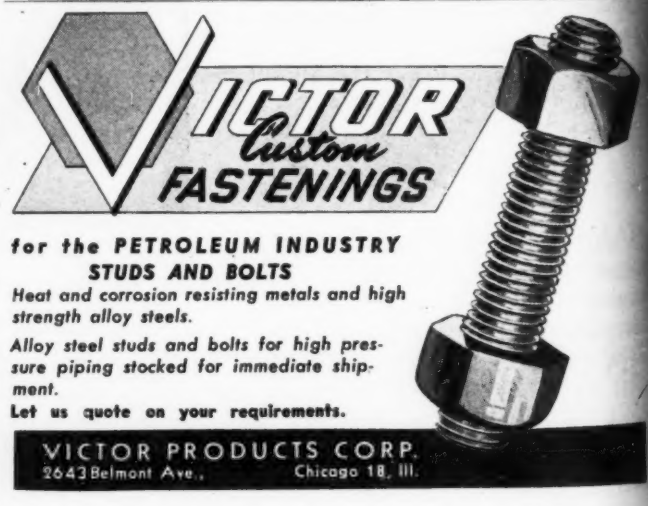
Owing to the volume and detail of electrical and wire rope business, two separate divisions have been created to handle the sales of electrical products and wire rope and construction materials. P. T. Coons, formerly head of the electrical, wire rope and construction materials department, which is being discontinued, will assume the responsibilities as manager of the wire rope and construction materials division. T. F. Peterson has been appointed manager of the newly created electrical division. B. M. Ashbaucher has been made assistant manager of the wire rope and construction materials division, and C. H. Eisenhardt has been named to a similar position in the electrical division.

Opens New Tulsa Office

Fairbanks, Morse and Company announces the opening of a new office in Tulsa, Oklahoma. The office is under the management of Frank D. Ratcliffe, district manager, oil industry sales, and is at 1335 Hunt Building.

Carbide Directors Elected

At the annual meeting, stockholders of Union Carbide and Carbon Corporation elected Ralph R. Browning, Paul P. Huffard, and Homer A. Holt to the board of directors. Browning has been associated with units of Union Carbide and Carbon Corporation for 31 years, and Huffard for 35 years. Both have been vice presidents of the corporation since 1939.



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